National Renewable Energy Laboratory

FY2001 Sustainability Report

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1. PREFACE

This report builds upon the foundation provided by the National Renewable Energy Laboratory (NREL) *Sustainable NREL Baseline Data* report (July 2000) and the continuing work of the Sustainable[1] NREL team to determine NREL's current situation and to identify and implement strategies that will enable the Laboratory to improve its environmental and social performance while continuing to maintain or improve its financial health. It includes information and indicators for the environmental, social, and financial performance of NREL, identifies remaining challenges the Laboratory faces, and identifies and evaluates strategies to address those challenges.

This report is primarily directed toward addressing NREL's environmental performance, since this is an area that has traditionally received less attention than financial performance or social issues. Meeting regulatory requirements and ensuring employee safety through proper environmental health and safety controls has been a consistent focus of NREL. However, progressing beyond these realms to evaluate how the operation of NREL broadly affects the environment and the ways in which operations can be changed to improve performance is a relatively recent development. Therefore, there are many opportunities for evaluating the Laboratory's performance and help it progress toward sustainability.

The initial sections of the report include an organizational profile of NREL and a discussion of what sustainability means for NREL and how to measure and evaluate sustainability. The body of the report contains a brief discussion of NREL's financial performance, followed by discussion of environmental considerations—including sections on land use, energy, transportation, water, materials procurement and disposal, and integrated management—and a review of social considerations. The report concludes with suggestions for quantitative measures of financial, environmental, and public considerations in the form of scorecards.

This work was prepared primarily by Jake Swenson, a graduate student at the Center for Sustainable Systems at the University of Michigan during the summer of 2001, under the guidance of two NREL staff members, Lynn Billman and Margaret Mann. Numerous other NREL contributed to this work, including (but not limited to):

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[1] Please see section 3.2:What Does "Sustainable" Mean? for a description and definitions of the sustainability concept.

2. ORGANIZATIONAL PROFILE

The National Renewable Energy Laboratory (NREL) is a leader in the effort by the Department of Energy (DOE) to secure an energy future for the nation that is environmentally and economically sustainable. NREL's mission is to lead the nation toward a sustainable energy future by developing renewable energy technologies, improving energy efficiency, advancing related science and engineering and facilitating deployment.

A federally funded research and development center established in 1977, NREL is owned by DOE and managed by the Midwest Research Institute, Battelle, and Bechtel under the direction of the DOE Golden Field Office. Headquartered in Golden, Colorado, NREL currently has approximately 900 payrolled employees in its laboratories and offices. Other than a small staff of specialists located in NREL's Washington, D.C. office, all staff are housed in Golden.

2.1. VISION

NREL will be the world's preeminent institution for advancing innovative renewable energy and energy efficiency technologies from concept to adoption. By partnering with our stakeholders, we will support a sustainable energy future for the nation and the world. In achieving this next level of excellence, NREL will set the standard for others.

NREL's vision for the future is a world in which:

- access to energy resources and their consumption does not degrade the environment or depend on the political stability of oil producing nations;
- all people can take advantage of their indigenous energy resources;
- resources are managed as integrated systems in the sense of industrial ecology;
- energy sources are renewed or replenished rather than exhausted, and;
- all people will have the energy required to support economic development to enable access to adequate food supplies, medical services, education, and the general lifestyle enjoyed today only by a small portion of the world's population.

2.2. RESEARCH AREAS

NREL fulfills its mission and pursues its vision through a number of various research and development programs. NREL conducts the great majority of its work for DOE's Office of Energy Efficiency and Renewable Energy (EERE), supporting EERE's mission to develop advanced energy efficiency and clean power technologies and practices. The programs and activities that NREL manages and conducts on EERE's behalf include:

Photovoltaics — investigate and develop advanced solid-state materials, technologies, and systems for turning sunlight into electricity

Wind Energy — develop and test advanced technologies for converting wind energy into electricity

Biopower — develop and expand use of materials and technologies for combusting biomass to generate electricity and process heat

Concentrating Solar Power — develop systems and materials for producing power from concentrated sunlight

Solar Buildings — advance the development of thermal and electric solar technologies for use in buildings

Hydrogen — research and validate technologies to enable renewable hydrogen to make the transition to a major energy carrier for electricity, heat, and transportation

Geothermal Energy — develop advanced heat-transfer technologies for improving the performance of geothermal power plants

Distributed Power — develop, promote, and advance standards, codes, and technologies for integrating modular, distributed electrical generating systems into electrical grids

Superconductivity — research superconducting materials, wires, and tapes for use in highly efficient electrical transmission and storage

Biofuels — develop cost-effective and environmentally friendly technologies for producing alternative transportation fuels and fuel additives

Fuels Utilization — develop and evaluate advanced fuels for use in internal combustion engines and fuel cells

Advanced Automotive Technologies — develop, model, and analyze systems for hybrid electric vehicles

Buildings Technologies —develop, promote, and integrate energy technologies and practices to make buildings more efficient

2.3. STAKEHOLDER RELATIONS

Partnerships are critically important at NREL. The Laboratory has been building a foundation of partnerships since its inception, integrating the expertise of industry, academia, and DOE to solve complex technical problems. In any given year approximately half of NREL's funding returns directly to the private sector through subcontracts, cost-shared research agreements and procurements. Research partners include more than 70 universities, 250 companies, 25 state energy offices and 80 not-for-profit organizations.

2.4. FISCAL AND HUMAN RESOURCES

For information on financial and human resource issues, see the Financial and Social Responsibility sections of this report. More detailed information about these areas is available via NREL's *Fiscal Year 2000 Business and Operating Results* report and *NREL's 2001 – 2005 Institutional Plan*.[2]

[2] *NREL's 2001-2005 Institutional Plan* is available online at http://www.nrel.gov/docs/gen/fy01/29306.pdf

3. SUSTAINABLE NREL

While NREL's mission and vision directly contribute to the sustainable development of the energy sector on a global scale through the advancement of renewable energy technologies and energy efficiency, we also recognize that the way we conduct our operations and invest in our Laboratory is important to our future. Therefore, we have launched the Sustainable NREL initiative, an effort to incorporate the principles of sustainable development into the Laboratory's everyday operations and decision-making. Other than the many benefits such a program can produce, one major goal of the process is to allow NREL to become a sustainability leader and mentor for other organizations.

3.1. SUSTAINABLE NREL VISION STATEMENT

NREL will exemplify sustainability in an R&D organization by maximizing efficient use of all resources, minimizing waste and pollution, and serving as a positive force in economic, environmental, and community responsibility.

3.2. WHAT DOES "SUSTAINABLE" MEAN?

Sustainable development can be defined as the simultaneous pursuit of economic prosperity, environmental health, and social equity over the long-term time horizon. This is often referred to as managing to a "triple bottom line".[3] Sustainability—whether for an organization, nation, or the world—can be defined as the endpoint of the long road of sustainable development in which economic prosperity, environmental health, and social equity exist in harmony. Figure 1 helps to illustrate the notion of sustainability.

Perhaps a more tangible definition of sustainability for firms and organizations is provided by the Lowell Center for Sustainable Production. According to the Lowell Center, sustainable companies and organizations create " … goods and services using processes and systems that are non-polluting, conserving of energy and natural resources, economically efficient, safe and healthful for workers, communities, and consumers, and socially and creatively rewarding for all working people."[4]

Many industrial ecologists—scientists who study the material and energy flows of industrial processes and operations—would define sustainable organizations even more strictly. They would argue that truly sustainable industrial systems would operate like biological systems, in which no waste is created that is not of high value to other organisms in the system, and where the system functions using renewable energy and materials. This ideal state of operations would

[3] Adapted from World Business Council for Sustainable Development definition. http://www.wbcsd.com/aboutdfn.htm#ps (June 2001).
[4] Lowell Center for Sustainable Production. www.uml.edu/centers/LCSP (June 2001).

be the ultimate goal for all organizations progressing toward sustainability, albeit a goal for the distant future.[5]

Figure 1: The Concept of Sustainability[6]

Realistically, options such as using only renewable energy for operations, completely eliminating waste, or using only bio-based materials in operations are too costly or not even a possibility in the near term. An organization that immediately pursued such options might go out of business due to the costs incurred. Balancing these three goals of sustainability requires careful consideration of the economic, social, and environmental impacts of an organization's operations and its plans for the future.

3.3. POTENTIAL SUSTAINABLE NREL GOALS

Considering the various sustainability concepts described above, as well as consideration of other common views of what it means to be sustainable, NREL has identified a number of sustainability goals that it will endeavor to follow. More specific goals are being developed in many areas. These specific goals are explained in relevant sections of the report and are summarized in the executive summary. Overall potential goals for Sustainable NREL are described below:

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[5] The idea that industrial system should function as an analog to natural systems, often referred to as the "nature-as model" theory, was first proposed in 1989 by Frosch and Gallopoulous. See Braden R. Allenby, "Achieving Sustainable Development through Industrial Ecology," International Environmental Affairs, 4(1), pp 56-68.

[6] Adapted from a diagram in Conoco Sustainable Growth Report: A Look at our Progress, Conoco, Inc. May 2001, p. 9.

3.3.1. Financial Goals

- Efficiently manage fiscal resources to continue to lead the nation and world toward a sustainable energy future.

3.3.2. Environmental Goals

Land Use

- Maintain, protect, and restore adjacent natural and landscaped environments to sustain natural and native ecological systems.
- Minimize the environmental impacts of NREL's built environment through the use of environmentally preferable designs and technologies.

Energy

- Minimize energy use in all operations.
- Maximize the use of renewable energy supplies via on-site generation and energy purchase.

Transportation

- Build and maintain a vehicle fleet that is the most environmentally preferable possible while still meeting performance, cost, and regulatory requirements.
- Empower and encourage employees to choose the least energy intensive and polluting form of transportation to and from work and while engaged in work-related travel.

Water

- Conserve water and minimize water consumption and wastewater discharges throughout NREL operations.

Materials Procurement and Disposal

- Minimize the use of materials and energy and the creation of waste by reducing, reusing, recycling, buying recycled, and composting.
- Purchase and use recycled content, biobased, and energy efficient materials and products whenever fiscally possible and appropriate.

Integrated Management

- Develop systems, procedures, and policies and direct resources to enable staff to most easily measure performance, pursue initiatives, and develop projects to improve NREL's sustainability.
- Work with research and technology development staff to foster the design of products and technologies that are affordable; safe and ecologically sound throughout their life cycle; designed to be durable, repairable, readily recycled, compostable, and/or easily

biodegradable, as appropriate; and, produced and packaged using the minimal amount of materials and energy.[7]

- Conduct life cycle assessments when feasible to identify opportunities for reducing the environmental impacts of NREL's operations.[8]

3.3.3. Public Responsibility Goals

- Provide a safe, enjoyable, diverse, and rewarding work environment for all of its employees
- Support local communities in which NREL operates by being a friendly, supportive, socially-responsible neighbor.
- Educate and encourage other organizations to become more sustainable.

NREL has already incorporated many of these goals into its operations, partially because a number of these goals are directly addressed in Executive Orders (EOs) or DOE Directives, which have targets that all federal agencies must meet with respect to energy use, energy efficiency, water conservation, waste reduction, etc. However, the Sustainable NREL initiative is not just a response to federal mandates, but is also intended to address issues outside of established federal program requirements. Therefore, several other programs have been initiated as part of the Sustainable NREL initiative. The existing Sustainable NREL programs and accomplishments, remaining challenges, and proposed or current projects intended to improve performance are discussed throughout this report.

While the general principles outlined above are useful guides for NREL, a major challenge the Laboratory faces is how to evaluate projects that are suggested for consideration and select those that will most effectively steer NREL toward sustainability. Selecting those strategies and projects that most effectively promote sustainability requires sound evaluation.

3.4. MEASURING SUSTAINABILITY

Performance with respect to sustainability is generally measured through the use of various metrics that quantify or qualitatively describe financial, social, and environmental characteristics on an annual basis.

Financial metrics typically measure commonly reported items such as:

- sales or budget;
- amount spent on research and development, and;
- operating costs, maintenance costs, and other costs.

Social metrics might measure factors such as:

- racial and gender diversity;
- lost workdays;

[7] Ensuring that these principles are incorporated into product design is often referred to as life cycle design. Adapted from Lowell Center for Sustainable Production. www.uml.edu/centers/LCSP (June 2001).
[8] See section 3.5.1.2 for an explanation of life cycle assessment.

- charitable donations, and;
- employee job satisfaction.

Environmental metrics might measure factors such as:

- electricity use;
- fuel use;
- emissions of greenhouse gases and ozone depleting substances;
- solid, hazardous, and radioactive waste disposal, and;
- land preservation.

Metrics specific to NREL in these areas are incorporated throughout this report.

3.5. EVALUATING &IMPROVING SUSTAINABILITY—SUSTAINABILITY CRITERIA

While measuring sustainability through the use of metrics is essential for identifying the current performance level of an organization, it does not indicate the best ways in which to improve performance. Evaluating options for improving sustainability requires the use of criteria that enable decision-makers to evaluate alternative proposals across various aspects of sustainability. Those projects with the greatest overall benefits relative to costs generally should have the highest priority for an organization.[9] The easiest decisions are those which result in immediate savings (or a rapid payback) for the organization and create additional environmental or social benefits. Examples could be the identification of a less costly and more environmentally friendly alternative to an office or laboratory product, waste reduction, and low-cost policy changes that result in energy savings.

Sustainability criteria attempt to quantify the financial, environmental, and/or social benefits of a project to reveal how and to what degree the project will improve performance and to compare projects across these criteria.

Financial criteria used to evaluate the project may include:

- capital and operating costs;
- simple payback;
- discounted payback;
- internal rate of return (IRR), and;
- life cycle cost analysis (see section 3.5.1.1).

Environmental criteria used to evaluate the project may include:[10]

[9] The notion of benefits and costs as used in this context includes financial, environmental, and social benefits and costs. Some organizations may be willing to incur a higher operating cost for on-site daycare or other employee benefit programs while others might determine that the environmental benefits of renewable energy are worth the additional financial cost.

[10] Ideally, most environmental criteria would be measured across the entire life of the project or product, especially when two or more products or processes are being compared. This method of evaluation, called life cycle assessment, is explained in section 3.5.1.2.

- energy savings;
- greenhouse gas emissions avoided;
- criteria air pollutant emission reductions;
- water saved;
- solid waste reductions;
- materials recycled or reused;
- open space preserved;
- toxic waste reduced, and;
- how the project helps fulfill the environmental goals or requirements in federal regulations, executive orders, or DOE orders.

Social criteria may include, among other things, qualitative or quantitative assessments of how the project is expected to affect:

- employee performance and/or happiness;
- job creation
- employee injury rates;
- racial, ethnic, and gender diversity; and
- community relations.

Whenever possible, NREL has included sustainability criteria in its evaluation of projects. For example, for projects related to energy use, NREL has estimated energy savings and resultant air emission reductions expected for most projects. NREL has also tried to determine how the project will affect achievement of federal goals and requirements. However, the benefits and costs of many projects ideas cannot always be quantified until the project is actually implemented. In other situations, more in depth analysis may be necessary before a decision is made concerning project feasibility and impacts.

3.5.1. Analytical Tools for Sustainability Analysis and Improvement

A number of comprehensive analytical tools exist that can be used to help evaluate ideas for improving organizational sustainability and measure impacts. When appropriate and feasible, the sustainability tools listed below could be used to assist in evaluating future proposed projects at NREL. A few projects currently in development are using, or are expected to use, some of these evaluative tools.

3.5.1.1. Life Cycle Cost Analysis (LCCA)[11]

Life cycle cost analysis (LCCA) is a method for evaluating all relevant costs over time of a project. LCCA has been used for many decades by engineering firms, government agencies, and various businesses. The LCCA method takes into account first costs, including capital investment costs, purchase, and installation costs; future costs, including energy costs, operating costs, maintenance costs, capital replacement costs, financing costs; and any resale, salvage, or disposal cost, over the life-time of the project. LCCA is particularly suited to the evaluation of design alternatives that satisfy a required performance level, but that may have differing

[11] Also referred to as life cycle cost analysis, total cost accounting, or technoeconomic analysis (TEA).

investment, operating, maintenance, or repair costs; and possibly different life spans. Under Executive Order 13123, LCCA is required to be used for all projects intended to reduce energy and water use.[12] According to Federal Energy Management Program (FEMP) guidance on LCCA use for EO 13123, if the costs are insignificant and the project saves energy or water over its lifetime, then the project is considered cost-effective for agency-owned buildings.[13]

3.5.1.2. Life Cycle Assessment (LCA)[14]

Life cycle assessment measures the environmental impacts of a product, process, or system rather than simply the financial impacts, like LCCA. However, LCA may also include an LCCA in its analysis to provide a comprehensive picture of both environmental and financial impacts. Numerous guides and standards exist describing the proper procedures and accounting processes required for LCA from sources such as U.S. EPA and the International Standards Organization (ISO).

In LCA, material and energy balances are used to quantify the emissions, resource depletion, and energy consumption of all processes required to make the product or operate the process of interest. The processes measured include raw material extraction, transportation, processing, and final disposal of products and by-products.[15] The results of this inventory are then used to evaluate the environmental impacts for a product or process or to compare to LCAs conducted of alternative products or processes. The results of an LCA can help to identify areas of a product manufacturing system or process that are inefficient or wasteful and can serve as a useful comparative tool. Executive Order 13101 encouraged EPA to include information on life cycle assessments to assist Federal agencies in determining which environmentally preferable products to procure.[16]

A study conducted for GM comparing steel versus high density polyethylene (HDPE) fuel tanks for use in automobiles provides a good example of how LCA can be used. The U.S. automobile industry has traditionally used steel fuel tanks for many years, but was considering whether to replace them with HDPE tanks. The LCA found that HDPE tanks were more energy efficient than steel across the life cycle even though energy use during material production and manufacturing was higher. Because of their lighter weight, the tanks helped to increase fuel efficiency compared to steel tanks, reducing overall emissions of the entire system. Even though HDPE tanks cannot currently be recycled like steel tanks, the solid waste impacts were not that much worse for HDPE when considered across the life cycle because steel material production produces significant amounts of solid waste. Air and water emissions related to the HDPE tank

[12] Adapted from Guidance on Life Cycle Cost Analysis Required by Executive Order 13123, Federal Energy Management Program, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, April 26, 2000.
[13] Ibid. See pp 10-11. Note that in leased buildings where energy and water costs are included in the lease payments and no savings for these utilities accrue to the agency in question, no projects are considered cost effective.
[14] Also referred to as environmental life cycle assessment or life cycle analysis.
[15] Adapted from a description provided by Margaret Mann, Senior Chemical Process Engineer, Chemistry for Bioenergy Systems, NREL.
[16] Executive Order 13101, Section 503.

system were lower than steel for most pollutants. This example shows the value LCA can have when comparing products with similar purposes.[17]

Several databases are now available that allow the comparison of various products or systems across the life cycle, such as Building for Economic and Environmental Sustainability (BEES) and Tools for Environmental Analysis and Management (TEAM). Many other LCA studies of packaging materials, construction goods, and products and processes have been conducted that can also serve as resources.

3.5.1.3. Environmental Economics

The full environmental impacts of natural resource extraction and use are not always internalized in the price of goods or services. While costs related to complying with environmental regulations and instituting environmental controls are ultimately passed on to consumers by businesses, many other impacts cannot easily be measured economically. Examples include the impact of sulfur dioxide emissions on water bodies via acid rain, the cost of losing forest resources for land development, the contribution of particulates to smog and respiratory problems, degradations in water quality from legal discharges of wastewater to a river, and methane emissions from landfills that contribute to global warming. The field of environmental economics attempts to place monetary values on such impacts through the use of a variety of economic models and valuation systems.[18]

Several states have recently developed cost estimates of the environmental effects of several air pollutants produced by electricity production. As of 1995, seven states had developed monetary values for air pollutants. In California, Massachusetts, and Wisconsin, externality values are required to be applied in the utilities' evaluation of procured energy and demand-side resources as well as any new capacity requirements. Thus, externality values were factored in when selecting future resource options within these States' integrated resource planning process.[19] The various estimates for air pollutants in dollars per ton are listed in Table 1.

The Environmental Protection Agency (EPA) and the National Park Service (NPS) have also placed monetary values on several pollutants to try and quantify the cost to the environment of energy use. The externality values used by EPA and NPS are also listed in Table 1 and were found on an NPS web site. EPA and NPS used externality values they developed along with emission factors derived for every state to determine an add-on monetary cost per kilowatt-hour (kWh) for energy use in a particular state.[20] Based on emission factors estimated for electricity

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[17] Keoleian et al., "Application of Life cycle Inventory Analysis to Fuel Tank System Design," International Journal for LCA, 3 (1) 1998.

[18] EPA's National Center for Environmental Economics (NCEE) has some useful information on how EPA is using environmental economics (http://www.epa.gov/economics/). A good introduction to the field is provided by Tom Tietenberg in *Environmental and Natural Resource Economics*, Fourth Edition, 1996. It should be noted that beneficial externalities are also priced using environmental economics.

[19] Department of Energy, Energy Information Administration, *Electricity Generation and Environmental Externalities: Case Studies*, 1995.

[20] Department of Interior Standards, *The Amount and Cost of Emissions Generated by Utilities and On-Site Sources.* September 1998. Emission factors for each air pollutant by state were based on Weisberg, P., *Green Lights Pollution Prevention Methodology*, ICF, Washington, D.C., 1991.

generation in Colorado, NREL could develop an add-on cost per kWh to account for environmental emissions when estimating the costs and benefits of energy projects.

Table 1: Environmental Externality Values Developed for Various Air Pollutants[21]

State or Entity	Air Pollutant Externality Values ($ per ton)						
	SO_x as Sulfur Dioxide (SO_2)	**Nitrogen Oxides (NO_x)**	**Carbon Dioxide (CO_2)**	**Particulates (PM_{10}) or TSP**	**Volatile Organic Compounds (VOCs)**	**Carbon Monoxide (CO)**	**Methane (CH_4)**
California*	$1,720	$7,467	$9	$4,608	$1,301	*NVS*	*NVS*
Massachusetts**	$1,500	$6,500	$22	$4,000	$5,300	$870	$220
Minnesota	$150	$850	$9.80	$1,274	$1,190	*NVS*	*NVS*
Nevada	$1,716	$7,480	$24	$4,598	$1,012	$1,012	NVS
New York	$1,437	$1,897	$1	$333	*NVS*	*NVS*	*NVS*
Oregon	$0	$3,500	$25	$3,000	*NVS*	*NVS*	*NVS*
Wisconsin	*NVS*	*NVS*	$15	*NVS*	*NVS*	*NVS*	$150
EPA / NPS	$1,700	$7,500	$14	*NVS*	*NVS*	*NVS*	*NVS*

* California has different values required for different areas of the State based on air quality attainment records. The values used here are for areas in attainment. The value under VOCs is technically the externality value assigned to reactive organic gases (ROG).
** The Supreme Court in Massachusetts ruled that the externality values developed could not be used because the MA Department of Public Utilities exceeded its statutory authority when prescribing the use of externality values. Note that the value under particulates is for total suspended particulate matter, not just PM_{10}.
NVS = No value stipulated; SO_x = Sulfur oxides; TSP = Total suspended particulates

Incorporating environmental externality values into calculations of costs incurred for a specific project is possible as part of LCCA. The use of such values in any sort of cost analysis is still a relatively new approach. As can be seen in Table 1, estimates of value vary.

3.6. CHALLENGES TO OPTIMIZING SUSTAINABILITY INVESTMENTS

Even with criteria for evaluation, difficult decisions remain concerning where to focus effort, especially when projects have similar costs but varying benefits (e.g., reduction of one ton of solid waste versus the reduction of 1,000 gallons of water use). In certain cases, judgements will often have to be based on organizational priorities, priorities in the community in which the organization operates, and other factors relating to relative environmental or social impacts.

For example, in a state or region with a large amount of available space in landfills but with limited freshwater supplies due to an arid climate, organizations might consider directing scarce resources to reducing water use and increasing water recycling where possible rather than further reducing solid waste. However, if price signals are not adequate with respect to scarcity of natural resources, as can be the case with water resources, a project defined as "lower priority" may be more cost-effective for the organization to implement.

[21] Department of Energy, Energy Information Administration, *Electricity Generation and Environmental Externalities: Case Studies*, 1995.

4. ENVIRONMENTAL CONSIDERATIONS

This section is organized around six major categories tied to environmental matters:

1. **Land Use**—Building design and construction activities and general land management activities.
2. **Energy**—Facility energy use (primarily owned buildings) and associated air emissions.
3. **Transportation**—Transportation related matters at NREL such as commuting, business travel, and the NREL fleet, as well as estimates of air emissions associated with transportation.
4. **Water**—Water use and wastewater.
5. **Materials Procurement and Disposal**—Purchase of materials to support NREL's operations. Solid, hazardous, and radioactive waste disposal as well as pollution prevention, reuse, and recycling.
6. **Integrated Environmental Management**—Overall management of environmental issues including policies, procedures, and systems.

Information provided for each category includes applicable federal targets, potential NREL goals, performance metrics and descriptions of accomplishments, and opportunities for improvement. Lastly, each section provides information on projects recently completed and projects in development or under consideration that are intended to improve performance.[22]

NREL uses the term "sustainability payback" as part of its project evaluation summaries. Sustainability payback as used by NREL refers to how a project will benefit the Laboratory's overall sustainability through its environmental and social benefits. NREL reviews financial information separately.

[22] Since a number of targets have been established through the "Greening of Government" series of Executive Orders (13101, 13123, 13148, 13149), many of the targets identified in this report are based on targets set in each EO or targets set by DOE in guidance for each EO.

4.1. LAND USE

This section presents a summary of NREL's built environment and land use patterns. It includes information on building design, construction activities, and general land management activities. For detailed information on NREL's current and proposed site development and land use patterns, consult NREL's 2000 Site Development Plan and 1999 Environmental Report. The 2000 Site Development Plan is available from Ed Weideman, while the 1999 Environmental Report is available from Maureen Jordan or John Eickhoff.

4.1.1. Federal Goals

Several executive orders contain broad targets for federal agencies related to land use. They are Executive Order 13148, "Greening the Government through Leadership in Environmental Management," and Executive Order 13123, "Greening the Government through Efficient Energy Management."

EO 13148, Section 207: Each agency shall strive to promote the sustainable management of Federal facility lands through the implementation of cost-effective, environmentally sound landscaping practices, and programs to reduce adverse impacts to the natural environment.

EO 13123, Section 403(d): DOD and GSA …shall develop sustainable design principles. Agencies shall apply such principles to the siting, design, and construction of new facilities. Agencies shall optimize life cycle costs, pollution, and other environmental and energy costs associated with the construction, life cycle operation, and decommissioning of the facility.…

4.1.2. Potential NREL Goals

NREL is committed to meeting federal targets and continuing to develop more specific goals as needed. Current goals identified are listed below:

General

- Maintain, protect, and restore adjacent natural and landscaped environments to sustain natural and native ecological systems.
- Minimize the environmental impacts of NREL's built environment through the use of environmentally preferable designs and technologies.

Specific

- Ensure that all future facilities exceed DOE/GSA sustainable design criterion and achieve at least a Gold rating under the Leadership in Energy and Environmental Design standards (LEEDs) of the U.S. Green Building Council.

4.1.3. Performance and Accomplishments

NREL conducts its operations in facilities at four locations in Golden, Colorado: the DOE-owned South Table Mountain (STM) facilities as well as leased facilities in the Denver West Office

Park (DWOP), the Joyce Street facility (JSF), and the 48th Street facility (48th). NREL also operates the DOE-owned National Wind Technology Center (NWTC) facilities, located 20 miles north of Golden, and leases office space in Washington, D.C. A summary of owned and leased buildings and the gross square footage occupied by NREL is available in the 2000 NREL Site Plan.

Table 2 lists the land use patterns for NREL as of 2000. Figure 2 visually displays the way available land is used at NREL.

Table 2: Land Use at NREL

Site	Total Land Area (acres)	Floor Area of all Buildings* (gross ft2)	Parking Lots and Roads** (acres)	Preserved area*** (acres)	Remaining Open Land Area (acres)	Estimated Land Area Available for Development (acres)
STM	327	333,305	14	191	114	46
NWTC	280	52,294	13	0	266	requires study
DWOP	-	178,198	-	-	-	-
Joyce Street	-	53,813	-	-	-	-
48th Street	-	4,572	-	-	-	-
D.C.	-	6,348	-	-	-	-
Total Owned	607	385,599	26	191	402	-
Total Leased	-	242,931	-	-	-	-
Total	607	628,531	1,189,060	191	402	-

* Floor areas for all buildings include all square footage in all floors occupied by NREL, and are not based on building footprint alone. Therefore, they overstate the actual land area occupied by the buildings. One acre equals 43,560 ft^2.

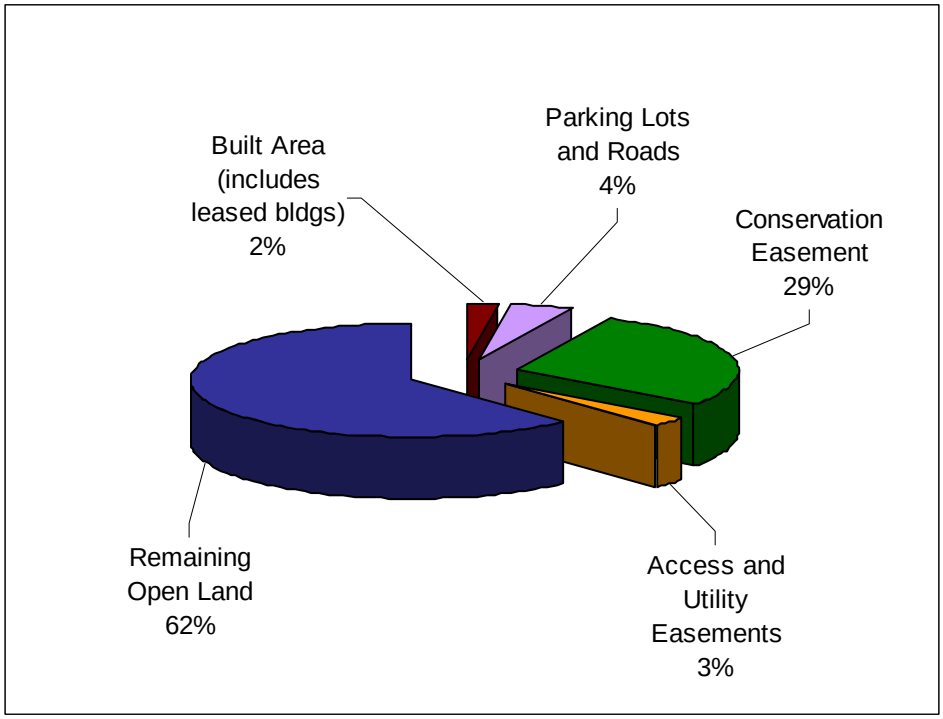
** Square footage for parking lots and roads is for owned buildings only. Information for leased sites is not currently available.

*** Preserved areas include approximately 175 acres for a conservation easement that was exchanged in 1999 for 25 acres of land on South Table Mountain for possible future development and 16 acres for utility and access restriction easements.

4.1.3.1. Built Space

NREL-owned buildings include both laboratory and office space, as well as support, storage, and maintenance buildings. Leased buildings at NREL are almost exclusively office space, with the exception of approximately 20 percent of the space in Building 16, which is available for limited laboratory use, and the Joyce and 48th Street facilities, which provide warehouse and storage space. DWOP is the location of all NREL Golden area leased office space. While NREL occupies all of its owned buildings, only part of some leased buildings are actually occupied. As of 2001, NREL occupied 9.1 percent of Building 15, all of Building 16, 70 percent of Building 17, and roughly 50 percent of Building 27 in DWOP. As evidenced in Figure 2, the buildings, parking lots, and roads that NREL maintains represent a small fraction of the total land area owned by NREL.

Figure 2: NREL Land Use Patterns



4.1.3.2. Open Space

As demonstrated in Figure 2, only about 6 percent of the land area owned or leased by NREL is developed. Of the remaining open land on the STM site (114 acres), 40 percent at most is estimated to be available for further development (46 acres). It is currently unknown what remaining open land at the NWTC site is available for development. In 1999, 175 acres of NREL land north of the STM site and adjacent to existing Jefferson County, CO open space was placed under a conservation easement in exchange for 25 acres of developable Jefferson County owned land to the south of the STM site. This easement helps to preserve the natural character of the property and open space opportunities in a region experiencing rapid growth.

4.1.3.3. Land Management

NREL has conducted numerous assessments of its owned lands to ensure that it does not adversely impact the local environment through site development or operations:

- Several periodic surveys of vegetation on STM and NWTC lands have been performed in 1993 and 1999 to characterize and document any impacts on vegetation from site development, none of which have identified existing threatened or endangered species on these owned sites. Drainage wetlands of less that 1 acre were identified on the STM site. The NWTC vegetation survey also identified small wetland areas and a rare tallgrass prairie plant community that NREL will protect from adverse impacts through designated conservation management areas. These will be protected from adverse impacts as site development continues. A new vegetation survey of the STM site was begun in June 2001 and will be finished approximately June 2002.

- Environmental Assessments (EA) for each of its owned sites and for individual facilities or proposed activities, as required by the National Environmental Policy Act (NEPA). Several EA's have already been completed for the STM site, and an EA for the NWTC site was completed in 1996. A new EA is scheduled to be completed for the NWTC site in 2001 and for the STM site in 2002.

- A wildlife survey of the STM site in 1987 which found no endangered species or species of concern on the site, a survey of the conservation easement property in 1999 which found no threatened or endangered species.

- Two cultural and historic surveys in 1980 and 1987 which led to the identification of two significant historical cultural resources that are now preserved, including a stone amphitheater with a stone bridge leading to it, and an ammunition bunker. All of these were constructed in the 1930s and have been added to the National Register of Historic Places.

- Field research into the possible impacts of the wind turbines at NWTC on birds (particularly raptors) was conducted in 1994 and 1995. No findings of significant impacts to birds were found. A new three-year avian study is underway, scheduled to be completed in spring 2002.

Landscaping, grounds maintenance, and irrigation at all NREL-owned sites is minimal. NREL's goal is to preserve the natural state of the surrounding landscape. However, some drought-resistant non-native plant species are located adjacent to some of NREL's owned buildings. Weed control for diffuse knapweed and Canada thistle has been the primary landscape management effort on owned sites over the past several years, and has been accomplished through the use of preventative measures, chemical sprays, or mowing. Reseeding of disturbed areas is accomplished via the use of native seed mixes.

4.1.3.4. Green Building

NREL recently had some employees trained to certify buildings to Leadership in Energy and Environmental Design (LEED) standards. The LEED Green Building Rating System™ is a program of the US Green Building Council. It evaluates environmental performance from a "whole building" perspective over a building's life cycle and allows the ranking of buildings on a similar scale. LEED is designed for those designing constructing new buildings, but aspects of the system outside of the ranking structure could also be helpful to evaluate to what degree an existing building is "green." NREL intends to use the expertise of its newly trained employees to help pursue accreditation of the planned Science and Technology Facility (STF) to a "Gold" rating, the second highest level possible. Based on the current design plans, the building would achieve a "Silver" rating. NREL hopes to improve this rating through a revision of the design plans, where feasible.

Similar to the LEED guidelines, NREL has formulated its own set of guidelines concerning site planning and development designed to help ensure that future construction is accomplished with the least amount of impact on the surrounding land and community while enabling NREL to most effectively pursue its mission and meet employee needs. These guidelines are designed to minimize the impact of site development on the land and its wildlife, incorporate green building designs such as daylighting and energy efficiency, ensure that built structures are harmonious

with their surroundings, and ensure that designs and developments are flexible, cost-effective, and provide an enjoyable, productive workplace.[23]

4.1.4. Opportunities for Improvement

NREL's overall site planning strategy is to maximize the use of DOE-owned facilities. Therefore, the Laboratory is exploring options for continuing to develop the STM and NWTC sites as needed to build permanent DOE-owned research facilities. NREL currently faces several challenges concerning its land use and built space.

- Constructing new facilities on the STM site for employees would free NREL from more costly leasing arrangements and reduce energy demand per employee compared to leased buildings since buildings constructed for NREL are designed to maximize energy efficiency while leased sites are not. It would also integrate staff on the STM site and reduce the need for vehicular travel between buildings. At the same time, such construction would represent further development of open land on the STM site, and so would necessitate weighing the costs and benefits of such a move.

- The STF building was designed to incorporate environmentally-friendly and energy efficient technologies, but a greater incorporation of such technologies could be achieved. It may not be possible to alter the design the building cost-effectively in order to achieve a "Gold" LEED rating since the building is already in the later design stages. This example points to the challenge of thoroughly evaluating and incorporating green design principles at the outset of a project.

- NREL lacks certain policies and procedures for ensuring that energy efficiency and environmental considerations are made before any major maintenance or construction project.

- Leased buildings are neither energy efficient nor designed to be "green" in other ways. Landscaping for leased sites is intensive for the Golden DWOP site, with numerous non-native species, widespread irrigation, pest and weed control, and artificial ponds and waterways. Addressing these issues is a challenge facing NREL.

4.1.5. Recently Completed Projects

A description of the projects Sustainable NREL has completed to date including sustainability payback, costs, and other pertinent information is provided in the following sections. While there were many projects completed related to land use as part of site operations, including construction and the environmental assessments mentioned previously, those types of projects are not listed here.

[23] General Guidelines and Considerations for NREL development planning are located in Appendix A of the 2000 Site Development Plan.

4.1.5.1. Conservation easement

As previously described, NREL permanently placed 175 acres into a conservation easement in 1999 for 25 acres of land on South Table Mountain for possible future development.
Sustainability payback: When factoring the additional developable land acquired, the easement represents about 25 percent of all NREL owned land, while only about 6 percent of NREL lands are taken up by buildings, roads, or parking lots. The land placed into an easement borders adjacent open space and so contributed to expanding existing open space and protecting a larger area of habitat from development. In Jefferson County, an area of rapid growth, the decision by NREL to refrain from developing its parcel of land was welcomed.
Financial impact: The conservation easement required a one-time operating cost of $16,704 for employee labor related to putting the agreement together.[24]

4.1.6. Projects in Development or Under Consideration

NREL has identified several possible projects for implementation that could help further reduce the Laboratory's environmental impact. The projects are listed and generally described in the following sections. Each section includes the priority and status of the proposed project, a description, the sustainability payback, and estimated project costs. Table 3 provides a summary of these projects for ease of reference.

4.1.6.1. LEED Certification of the Science and Technology Facility

Use the LEED rating system to certify the planned Science and Technology facility (STF) to a "gold" rating. Currently the STF is anticipated to achieve a "silver" rating without design plan adjustments.
Status: Anticipate completing by the end of FY 2001.
Sustainability payback: By initially designing the STF to be as "green" as possible, NREL will achieve significant energy, water, and material savings possible and can improve operational savings through the most efficient sizing of HVAC systems. Otherwise, more costly and less effective retrofits would be required if NREL wanted to address inefficiencies after construction. LEED certification will further increase the visibility of NREL as a leader in building systems design and improve integration between NREL's research and operations arms.
Financial impact: A total of $250,000 in overhead that was already apportioned for STF plan review and completion will be used to support revisions of the STF design plans.

4.1.6.2. LEED Certification for Future Facilities

It is anticipated that all future facility development will be LEED certified. Two NREL employees were recently accredited to use LEED facility certification.
Status: Ongoing.
Sustainability payback: Establishing NREL team to certify buildings will help ensure that buildings and their landscaping are designed to minimize impacts on the surrounding environment. NREL will increase energy, water, and material savings and can improve operational savings.
Financial impact: Uncertain and variable, but essentially employee time for certification

[24] Source: Lynn Billman

Comments: Requirements in EO 13123 sec 403(d) prescribe the use of Energy Star® standards for building design, although they are currently unavailable for laboratory buildings. It is uncertain whether NREL will need to also certify to the Energy Star® standards. As is already prescribed in existing NREL policies, landscaping should maximize the use of native plants, be low maintenance, and complement the area's natural ecosystem type. For example, tree shading should be carefully considered due to the general lack of natural tree growth at both the STM and NWTC sites and the additional need for irrigation. However, tree shading may be appropriate in disturbed areas like parking lots where heat island effects are large, especially if the trees selected do not require irrigation once established.

4.1.6.3. Construct New Sustainable Research Support Building

Build a research support building that will allow NREL to vacate most of its leased space. Building could be certified to highest LEED rating.
Status: Under consideration
Sustainability payback:

- significantly reduce energy intensity of NREL operations since leased buildings are much less energy efficient than a new office building designed to NREL standards.
- improve water efficiency due to design principles
- support use of recycled and reused construction materials
- serve as another showcase of NREL building efficiency
- increase employee happiness by incorporating better design principles and workspace layout.
- bring NREL staff closer together geographically, reducing travel between buildings.

Financial impact: Relieves DOE of lease costs, but requires large capital investment and approval of Congress.
Comments: In a March 2000 meeting, NREL discussed the possibilities with DOE. While some progress was made, this will likely be a long-term effort. It may be in NREL's interest to evaluate potential environmental and financial savings (possibly across the life cycle) compared to the status quo to help encourage funding of the project.

4.1.6.4. Purchase Environmentally Preferable Construction Materials

NREL already looks to purchase environmentally preferable products as part of the requirements of EO 13101. EPA has designated a number of construction products as part of their Comprehensive Procurement Guide.
Status: Ongoing
Sustainability payback: Buying recycled generally reduces the life cycle energy use for materials and reduces the creation of waste.
Financial impact:
Comments: Unfortunately, some recycled materials, such as those for construction, are more costly than virgin materials.

4.1.6.5. Pervious Parking Lot and Walkway Construction

Consider using pervious parking lot design for all future construction.
Status: Under consideration.
Sustainability payback: Pervious materials allow water to percolate into the ground rather than contribute to storm-water drainage loads.
Financial impact: Unknown.

Comments: Cost, performance, availability will affect ability to implement.

4.1.6.6. Roadway Coloring

When installing new roadways or during roadway repair, color roadways with a light color.
Status: Under consideration.
Sustainability payback: Reduce heating effect of asphalt. Reduce temperatures in localized area.
Financial impact:
Comments:

4.1.6.7. Gray Water & Water Runoff Reuse

Gray water and runoff from buildings, parking lots, and roadways could be collected and used rather than discharged to sewer.
Status: Under consideration.
Sustainability payback: Reduce loading to sewers and the need for irrigation.
Financial impact: Costs likely to be high, especially for gray water reuse.
Comments: Grey water reuse will require on-site treatment and possible permitting. Might be possible to design future facilities to include gray water treatment, but it may be cheaper to reduce water use of faucets and toilets than to spend money for on-site treatment. Rainwater collection and storage is a possibility for irrigation assistance, but collection costs need to be investigated. Runoff can be mitigated in other ways through landscaping changes that channel water to natural areas for filtering through soil.

Table 3: Summary of Land Use Projects in Development or Under Consideration

ID #	Project Title	Priority	Sustainability payback	Financial Costs and/or Benefits				
				Payback	FY 2001	FY 2002	FY 2003	FY 2004
4.1.6.1	LEED Certification of the Science and Technology Facility		Minimize building impacts both in the construction and use phases. Ensure that NREL will continue to keep energy use low relative to other DOE labs.	NA	$250,000			
4.1.6.2	LEED Certification for Future Facilities		Minimize building impacts both in the construction and use phases. Ensure that NREL will continue to keep energy use low relative to other DOE labs.					
4.1.6.4	Construct New Sustainable Research Support Building		- reduce energy intensity of NREL operations - improve water efficiency - support use of recycled and reused construction materials - serve as another showcase of NREL building efficiency - increase employee happiness by incorporating better design principles and workspace layout. - bring NREL staff closer together geographically, reducing travel between buildings.					
4.1.6.5	Purchase Environmentally Preferable Construction Materials		Meet requirements and goals of EO 13101 and DOE directives.					
4.1.6.6	Pervious Parking Lot and Walkway Construction		Pervious materials allow water to percolate into the ground rather than contribute to storm-water drainage loads.					
4.1.6.7	Roadway Coloring		Reduce heating effect of asphalt. Reduce temperatures in localized area.					
4.1.6.7	Gray Water & Water Runoff Reuse		Reduce loading to sewers and the need for irrigation.					

4.2. ENERGY

As a national lab that focuses exclusively on renewable energy technologies and energy efficiency, NREL has directed its expertise toward its own facilities and operations for a number of years. Research conducted at NREL has therefore been directly applied to facility construction and operation. A review of general federal targets related to energy use at federal facilities is followed by NREL's performance and accomplishments in a number of areas related to energy use. Due to the comprehensive extent of federal targets in different areas, more specific goals are listed in relevant sections.

4.2.1. General Federal Goals

A number of regulations, executive orders, and DOE directives affect the manner in which federal agencies are supposed to manage energy use in their owned facilities. The general coverage of these various instruments are described below. Due to the number of targets, specific targets established the various laws, orders, and directives are listed under appropriate sub-headings. NREL pledges to meet or outperform all federal agency goals. Potential NREL Goals, if more strict, are listed below the specific federal agency goals. The general goals developed by NREL regarding energy are listed below:

10 CFR 435: Specifies mandatory energy conservation performance standards for construction of all new federal commercial or multi-family high-rise buildings.

Energy Policy Act of 1992 (P.L. 102-486), Section 543(b): Prior to Jan. 1, 2005, each agency, to the extent practicable, shall install in Federal buildings all energy and water conservation methods with payback periods less than 10 years, as determined by using the methods and procedures developed pursuant to Sec. 544, "Establishment and Use of Life Cycle Cost Methods and Procedures."

EO 13123: Numerous requirements, including targets for building energy efficiency, renewable energy acquisition, guidelines for source energy consumption and composition, life cycle analysis, and other aspects of energy use.

DOE Goals and Orders: Several related DOE orders and recommendations have set specific goals for DOE owned offices and laboratory facilities. Draft DOE Order 430.2x will incorporate the provisions of EO 13123 as well as internal DOE goals, which may exceed the requirements under EO 13123. Some of these internal DOE goals were outlined in "Fourteen New Pollution Prevention and Energy Efficiency (P^2E^2) Leadership Goals", issued in November 1999.

4.2.2. General NREL Goals

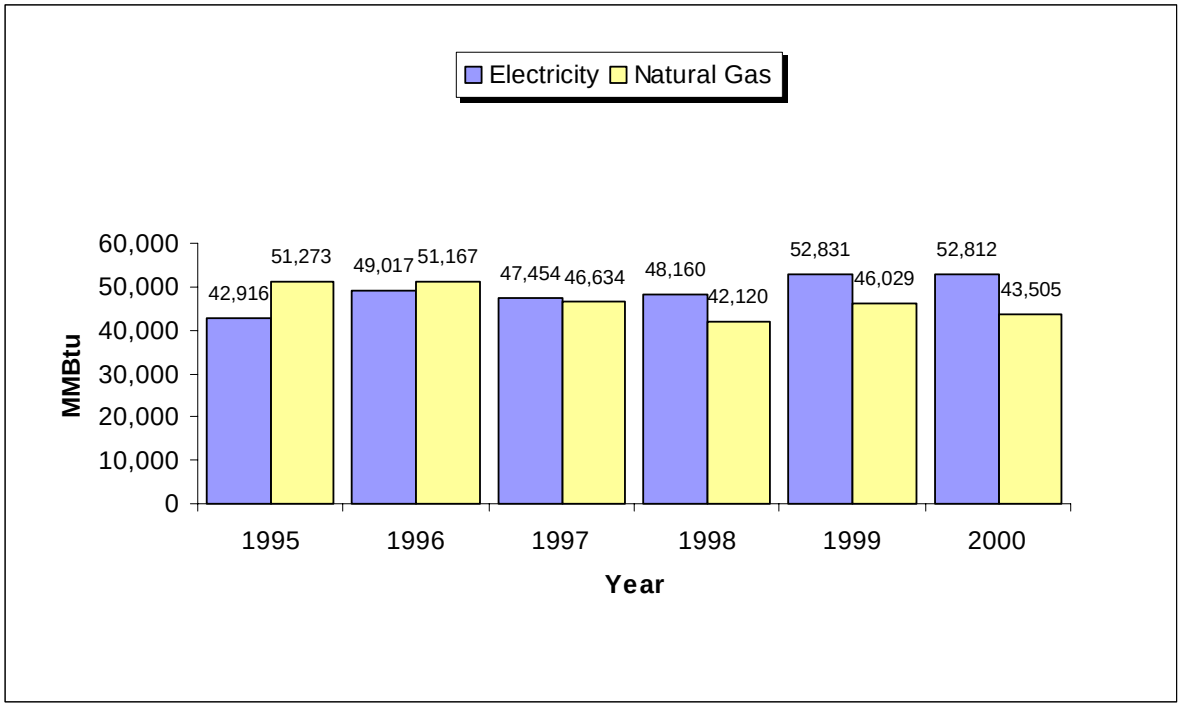
The following general goals encompass what NREL strives for with respect to energy. Specific goals are addressed in each applicable sub-section:

- Minimize energy use in all operations.
- Maximize the use of renewable energy supplies via on-site generation and energy purchase.

4.2.3. Performance and Accomplishments

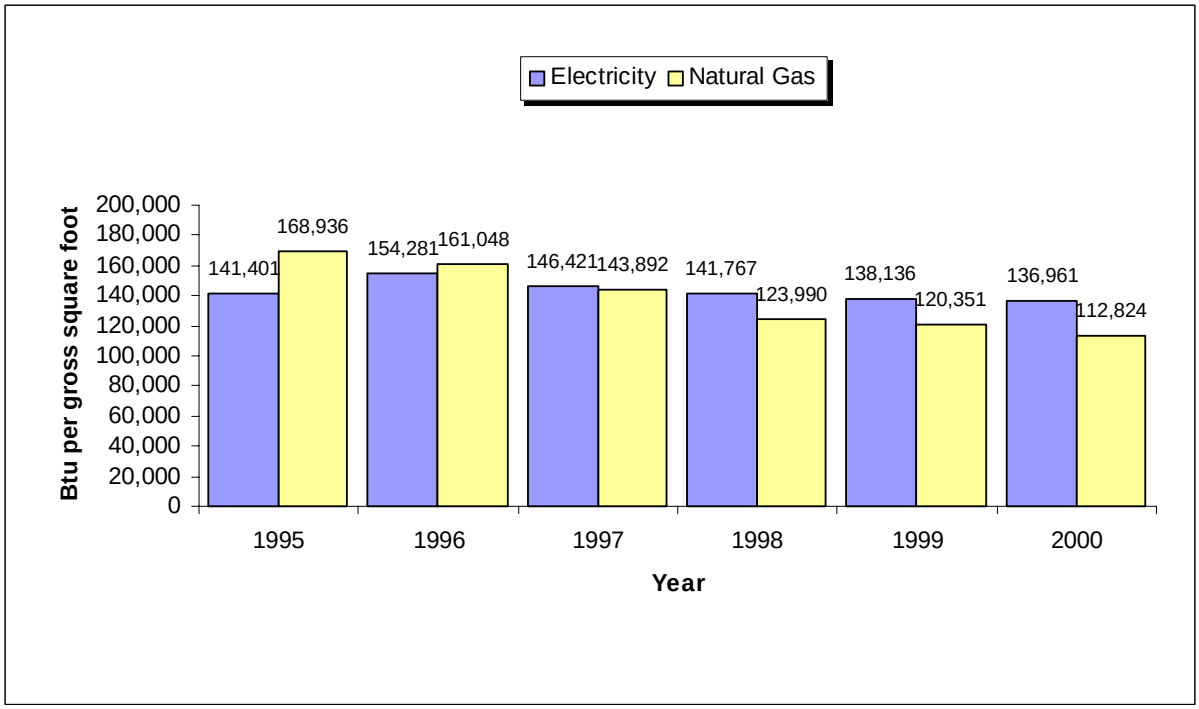
NREL is required to submit annual energy use data for owned facilities to DOE via DOE's EMS3 system. Figure 3 and Figure 4 provide information concerning NREL's energy use in owned buildings from 1995 to 2000 based on this data. The 48,000 kWh of wind-generated electricity that NREL has purchased at a premium since 1999 is included in the two figures. However, the electricity data does not include the solar energy that NREL generates on site from its photovoltaic panels, which helps meet NREL electricity demand. In 1999, the amount of electricity generated by these panels was estimated at approximately 52,133 kWh, or 178 million Btu (MMBtu). It can safely be assumed that a similar amount was probably generated in 1998 and 2000. Estimates of solar generation for previous years has not been estimated since on-site generation capabilities and estimated output has not typically been tracked.

Figure 3: Total Electricity and Natural Gas Consumption (Owned Facilities)



As demonstrated in Figure 3 and Figure 4, NREL's energy use for its facilities has fluctuated over the years, with electricity demand generally increasing and net natural gas usage generally decreasing, although both have declined significantly on a normalized basis. The following sub-sections address specific aspects of NREL's energy use. Most sections initially include information on any applicable federal goals or requirements, then discuss performance, and end with specific NREL goals based on federal goals and the Lab's performance.

Figure 4: Electricity and Gas Consumption per Gross Square Foot (Owned Facilities)



4.2.3.1. Electricity Costs

All electrical power purchased from Xcel Energy (formerly Public Service Company of Colorado (PSCo) is broken down into a direct charge per kilowatt-hour (kWh) and a demand charge. As of 2000, NREL paid a direct charge of $0.01612/kWh, which is a flat rate and does not change during the year. NREL also pays a flat meter charge of $125.00 for electrical service each month. In addition to the flat fees, two demand charges are made to NREL's electricity bill, an On-peak and an Off-peak demand charge:

On-peak Demand Charges: These charges are based on NREL's power use during times of the day where the utility company sees the largest power demand (generally 7 am to 6 pm). Xcel takes the top fifteen minutes of power use for each month and applies the demand charge during this time.

Off-peak Demand Charges: These charges are based on NREL's power use outside of peak times. During this time, Xcel takes the top fifteen minutes of power use for each month and applies the demand charge.

Due to demand charges, approximately 65% of NREL's electrical bill is based on 30 minutes of energy use each month when electricity use is the greatest. Reducing these demand charges has become a major goal of NREL energy efficiency efforts on site. A recently initiated metering and monitoring project should help reduce demand charges and increase overall efficiency in NREL facilities. When all charges are combined and averaged, NREL paid approximately $0.048 per kWh for electricity in 2000.

4.2.3.2. Natural Gas Costs

By April of 2000 the majority of NREL's natural gas was purchased from GSA/Tiger at a rate of approximately $3.50 per million Btu (MMBTU). Previously, NREL purchased all of its natural gas from PSCo at a rate of $4.44 per MMBTU in the beginning of 2000. NREL saved over 20 percent on its gas bill by switching to GSA/Tiger.

4.2.3.3. Energy Efficiency

Federal Agency Goals

Two different targets are applied to federal facilities under EO 13123, one for typical office buildings (Section 202), and another for laboratory and industrial facilities, or facilities which are primarily designed for laboratory research or industrial operations and hence are more energy intensive (Section 203). DOE has developed more ambitious targets for each of these categories under its P^2E^2 program ("Fourteen New Pollution Prevention and Energy Efficiency Leadership Goals," issued in November 1999). DOE has also informed NREL that it could measure its performance against the laboratory and industrial targets it has developed. Since NREL has already identified and implemented many energy efficiency measures in its facilities, NREL has developed stricter goals than DOE for its owned facilities:

EO 13123, Section 202: … each agency shall reduce energy consumption per gross square foot of its facilities, excluding facilities covered in section 203 of this order, by 30 percent by 2005 and 35 percent by 2010 relative to 1985.

DOE P^2E^2 goal for buildings: Reduction targets of 40 percent by 2005 and 45 percent by 2010.

EO 13123, Section 203, Industrial and Laboratory Facilities: Each agency shall reduce energy consumption per square foot, per unit of production, or per other unit as applicable by 20 percent by 2005 and 25 percent by 2010 relative to 1990.

DOE's P^2E^2 goal for laboratories and industrial facilities: Reduction targets of 20 percent by 2005 and 30 percent by 2010 relative to 1990.

Performance

NREL's energy use in Btu per square foot for all of its owned buildings from 1995 to 2000 is graphed against the goals of Sec. 202 of EO 13123 and DOE P^2E^2 building targets in Figure 5. In FY 2000, energy use at NREL for all owned buildings compared to EO 13123 and DOE goals was impressive. Compared to the 1985 DOE baseline for buildings, NREL reduced its energy use per square foot by 44.17 percent. Therefore, the laboratory almost meets the DOE 2010 goal for buildings as of 2000. Compared to the 1990 DOE baseline for laboratories, NREL has reduced energy use per square foot by 64.55 percent.

To compare NREL performance to that of DOE, NREL obtained DOE baseline data for 1985 and then calculated DOE-wide goals under EO 13123 and P^2E^2 based on this data.[25] Each target line in Figure 5 represents the maximum allowable energy use in Btu per gross square foot based on the identified goal. When NREL's total is below a target line, it means that NREL has performed better than the required target.

In Figure 6, the energy use in fiscal year 2000 of owned buildings that NREL determined are primarily laboratory spaces were graphed as a percentage of the 1990 DOE baseline for laboratories and industrial facilities, which is 667,659 Btu per gross square foot. Also included in Figure 6 is the overall average energy use for all NREL owned buildings. These figures were compared to DOE-wide goals for laboratory and industrial facilities under EO 13123, Section 203 and DOE's P^2E^2 program. When NREL's total is below a target line, it means that NREL has performed better than the required target. It is important to note that all data in Figure 6 is modeled except for the values for the TTF building and the entire NREL average (both in green), which are based on metered data. See section 4.2.3.6 for more information on the energy modeling and audits conducted at NREL.

NREL has also compared modeled and metered energy use in its owned buildings to what would be expected under 10 CFR 435. In Figure 7, NREL building values are graphed as a percentage of the energy efficiency required in 10 CFR 435. Similar to the previous figure, data for TTF and NREL are the actual metered amounts, while data for the other buildings is based on modeling.

[25] Data obtained from DOE's EMS3 system via Carter Ward. The FY 1985 DOE baseline energy use for DOE "Building" category facilities was 447,366 Btu per gross square foot. This compares to the FY 1990 DOE baseline for "Laboratory" facilities of 704,598 Btu per gross square foot.

Figure 5: Annual Energy Use of All NREL Owned Buildings Compared to Future Targets for DOE Buildings

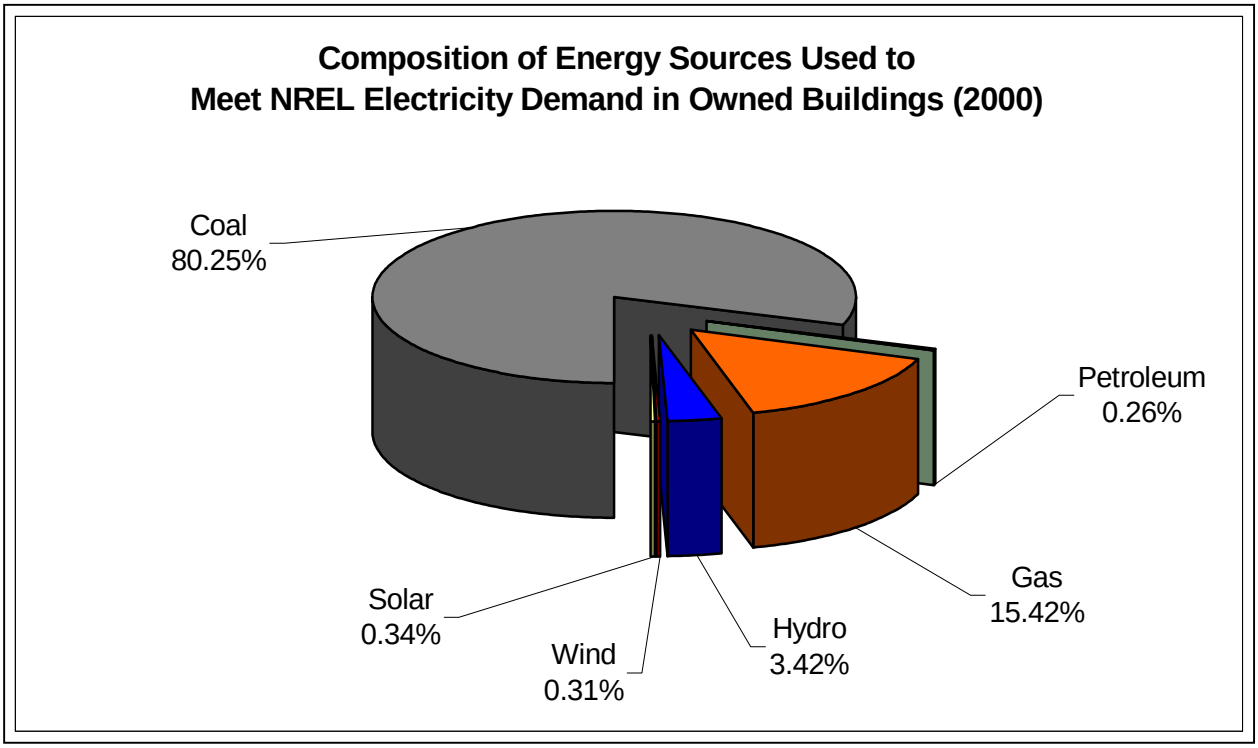


Figure 6: Energy Use in Owned Buildings as a Percentage of 1990 DOE Baseline for Laboratories and Industrial Facilities under EO 13123

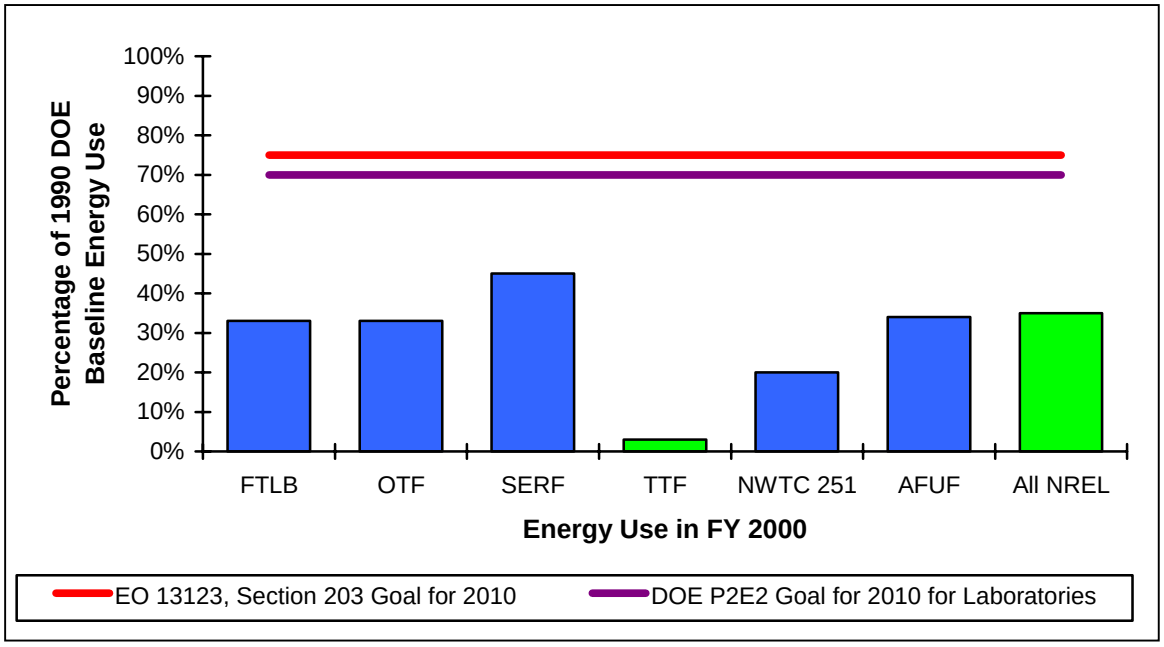
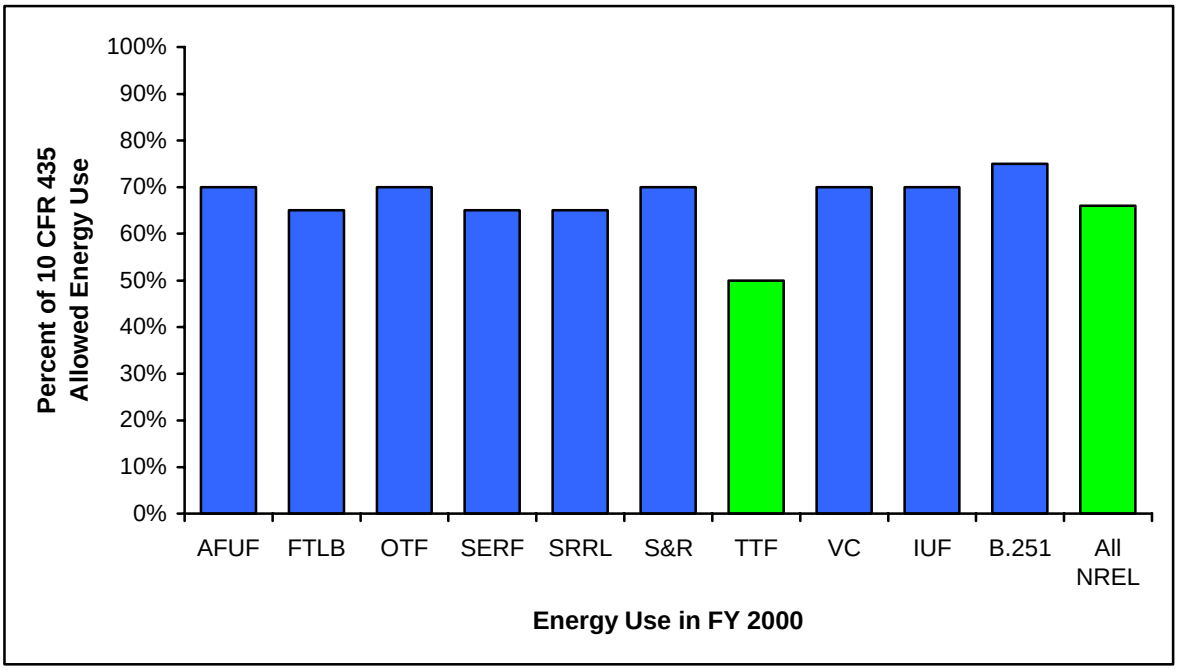


Figure 7: NREL Energy Use Compared to 10 CFR 435



Potential NREL Goals

- Strive to continue to exceed targets set by DOE for office buildings, even though NREL owned facilities are primarily more energy intensive laboratory space.

- Reduce energy use per square foot in owned buildings compared to the 1985 DOE buildings baseline by 47 percent by 2005 and 50 percent by 2010.

4.2.3.4. Renewable Energy

Federal Agency Goals
Several sections of EO 13123 and related DOE directives attempt to expand the use of renewable energy sources through goal setting:

EO 13123, Section 204. Renewable Energy[26]: Each agency shall strive to expand the use of renewable energy within its facilities and in its activities by implementing renewable energy projects and by purchasing electricity from renewable energy sources.

DOE Goal under Assistant Secretary for Energy at EERE David Garman: Assistant Secretary Garman recently arranged for DOE to be a founding partner of EPA's Green Power Partnership, and pledged that DOE facilities, including NREL, would supply 3 percent of their electricity from renewable sources by 2002.

- In September 2000, former Secretary of Energy Bill Richardson directed all DOE departmental elements to purchase 3 percent of their total electricity from non-hydro renewable sources by 2005, increasing to 7.5 percent by 2010.[27]

EO 13123, Sec. 404. Electricity Use. To advance the greenhouse gas and renewable energy goals of this order, and reduce source energy use, each agency shall strive to use electricity from clean, efficient, and renewable energy sources….

DOE's P^2E^2 Goals ("Fourteen New Pollution Prevention and Energy Efficiency Leadership Goals," issued in November 1999):

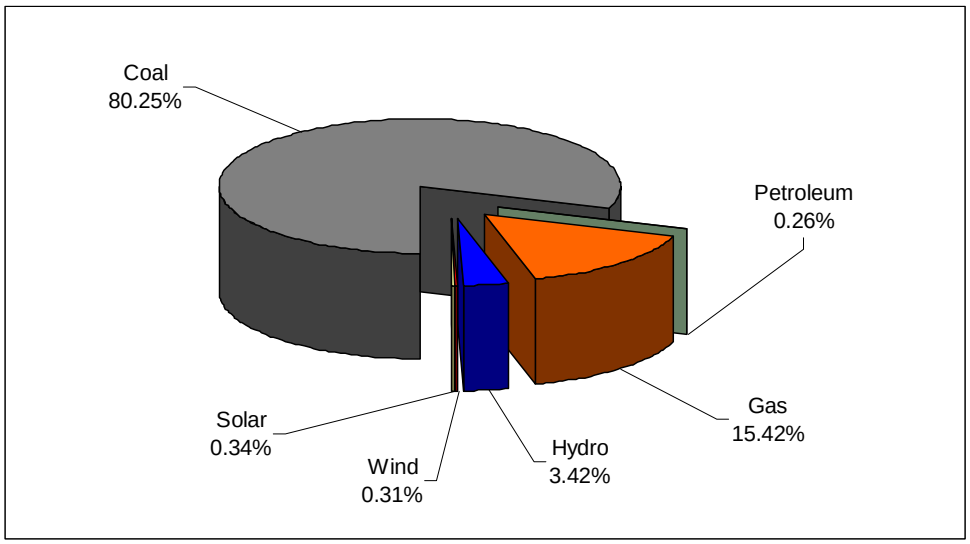
- Increase purchase of electricity from renewable energy sources by including provisions for such purchase as a component of our request for bids in 100 percent of all future DOE competitive solicitations for electricity.
- Increase the purchase of electricity from less greenhouse gas-intensive sources, including, but not limited to, new advanced technology fossil energy systems, and other highly efficient generating technologies.

Performance
Figure 8 shows the breakdown of electricity generated for NREL use. It is based on an analysis of DOE information on net energy generation by fuel source for electric utilities and nonutility electricity providers in Colorado as well as NREL on-site solar generation and wind energy purchasing data.[28] Since the vast majority of electricity that NREL uses is likely to come from

[26] Renewable energy as defined in EO 13123 and as defined in DOE directives and other guidance does not include hydroelectric power.
[27] Bill Richardson, Secretary of Energy. Memorandum for all Departmental Elements. September 7, 2001.
[28] Department of Energy. Energy Information Administration. Electric Power Monthly. Tables 8 – 13 and Tables 62 – 66, March 2001; Tables 8 – 13, December 1999; Tables 8 – 13, March 1999. NREL electricity use data from Site Operations staff. An attempt was made to determine the composition of fuels used by Xcel energy, NREL's electricity provider, and use this data, but the data was only available for one year. A comparison showed that Xcel owned generation and that for all of Colorado did not differ substantially.

Colorado, this is a more accurate estimation of actual source-level impact than a national average and allows the Laboratory to recognize the likely environmental impacts of its electricity demand.

Figure 8: Composition of Energy Sources Used to Meet NREL Electricity Demand in Owned Buildings (FY 2000)



As illustrated in Figure 8, Colorado electricity generators rely heavily on coal for electricity generation. The recent surge in nonutility generators running gas turbines has caused a decline in coal use and growth in natural gas combustion for electricity. From 1999 to 2000, coal use in Colorado declined by almost 3 percent, while natural gas use increased about the same amount.

NREL generates approximately 52,000 kWh[29] of on-site electricity annually from photovoltaic (PV) panels located throughout its site, from panels installed on the Solar Energy Research Facility (SERF), to the PV panels at its Outdoor Testing facility (OTF) and other smaller units scattered throughout the STM site. All of the PV panels help offset the electricity NREL purchases from the grid.

Since 1999, NREL has also purchased 48,000 kWh per year of wind-based electricity at a premium through Xcel Energy (the local utility). This is enough wind-based electricity to meet the Visitor Center's annual electricity use. In total, NREL obtained roughly 0.65% of the electricity purchased for owned buildings from renewable sources in 2000, about half of which was purchased wind energy and half generated on-site via PV panels. While NREL is contributing some electricity to Xcel Energy via its research wind turbines at NWTC, the turbines are not metered, so any additional offset credit NREL would receive from the turbines is currently unknown, and NREL receives nothing in return for its contribution. This situation is being resolved; see section 4.2.6.9 for more information.

[29] This figure is estimated, since not all PV panels are metered and not all data is collected for those that are metered.

Since April of 2000, NREL, in partnership with approximately 30 other Denver federal agencies, has been actively pursuing options to increase the amount of electricity it obtains from renewable sources. The most likely scenario for NREL will be to participate in Xcel Energy's Windsource program to a greater degree, which requires paying a premium of $0.25/kwh for wind-generated electricity.

As previously mentioned, David Garman recently arranged for DOE to be a founding partner of EPA's *Green Power Partnership*, and pledged that DOE facilities, including NREL, would supply 3 percent of their electricity from renewable sources by 2002. This promises to facilitate the purchase of renewable energy via one of these channels in the near future.

Potential NREL Goals

- Meet goal of acquiring 3 percent of total energy use from renewable sources by 2002, as directed by Assistant Secretary Garman.
- More closely track generation from PV panels and from NWTC turbines to enable accurate measurement of renewable energy generation.
- Generate at least 1 percent of electricity from on-site renewable sources by 2005.
- Increase proportion of energy from renewable sources to 5 percent by 2005 and 8 percent by 2010.

4.2.3.5. Source Energy

Source energy[30] is the energy required to generate, transmit, and distribute energy to the end user rather than just the energy used at the site by an end user. For electricity, it generally takes approximately 3.4 kW to deliver 1 kW to the end user when the inefficiencies of generation and transmission are taken into account. In contrast, a fuel that is burned on-site for energy will be more efficient with respect to source energy.

Federal Agency Goals

EO 13123, Sec. 206. Source Energy. The Federal Government shall strive to reduce total energy use and associated greenhouse gas and other air emissions, as measured at the source. To that end, agencies shall undertake life cycle cost-effective projects in which source energy decreases, even if site energy use increases. In such cases, agencies will receive credit toward energy reduction goals through guidelines developed by DOE.

Performance

As noted previously, NREL has estimated the ratio of energy sources used to provide NREL's electricity. This can enable NREL to reduce total energy use and associated greenhouse gas and other air emissions as measured at the source using life cycle analysis of cost-effective projects.

As an example of a project that may have source energy benefits without site energy benefits, NREL is conducting an analysis of converting electric boilers at its NWTC site to natural gas fired boilers to determine the payback period, energy use, and air emissions across the entire life

[30] Source energy may also be referred to as primary energy.

cycle. NREL anticipates that this project will prove to be more energy efficient across the life cycle and impose less of an environmental burden than the current system.

Potential NREL Goals

- Reduce total energy use and associated emissions as measured at the source through the development of projects that increase on-site renewable generation, renewable energy purchase, and the substitution of natural gas for other fossil fuel use when feasible.
- Keep track of source energy use and identify areas where it can be reduced.

4.2.3.6. Energy Audits

Federal Agency Goals

EO 13123, Sec. 402. Facility Energy Audits. Agencies shall continue to conduct energy and water audits for approximately 10 percent of their facilities each year, either independently or through Energy-Savings Performance Contracts or utility energy-efficiency service contracts.

Performance

NREL has conducted energy audits of all of its major owned facilities in an aggressive fashion. Currently these audits are based on DOE 2.1E modeling that has not been calibrated through the use of actual building process meters (except in the Thermal Test Facility). However, recent approval for funding to complete an ongoing metering project promises to provide building data to refine the model by 2002.

The following NREL buildings were audited and modeled with DOE2.1E in 1997 and again in 2000.

- Alternative Fuels User Facility (AFUF)
- Field Test Laboratory Building (FTLB)
- National Wind Technology Center (NWTC-251)
- Outdoor Test Facility (OTF)
- Site Entrance Building (SEB)
- Solar Energy Research Facility (SERF)
- Thermal Test Facility (TTF)
- Visitors Center (VC)

The energy performance of these owned buildings is graphed against goals under EO 13123 and DOE goals in Figure 6 and Figure 7. Even though building-by-building energy data is currently modeled, DOE 2.1E, a government-developed software program, has an excellent record:

- widely recognized as the industry standard, and it is the most frequently used government-developed program for building energy analysis in the United States and 40-plus other countries
- allows for detailed, hourly whole-building energy analysis of multiple zones in building of complex design
- has been validated by Los Alamos National Laboratory, Lawrence Berkeley National Laboratory, and universities to show that the program accurately predicts energy use in real buildings

- is used to develop state, national, federal, and international building energy-efficiency standards

The research procedures followed by NREL for the energy audits includes an in-depth study of construction plans, walk-through of the selected building, updating of the DOE2 computer simulation model, and selection of energy conservation measures (ECMs) and operation and management (O&M) changes. ECM and O&M selection is based on user complaints and observed inefficiencies. Actual cost savings and associated payback periods are determined using the DOE2 simulation software. Based on the most recent audit, NREL identified a number of energy efficiency opportunities. It is expected that additional strategies will be identified after the metering project is initiated.

By 2002, NREL anticipates having actual data for all owned buildings (excluding sheds and other small support structures), once the ongoing metering project has been completed. At this time, individual metering at the STM for electricity is incomplete; while meters have been installed in several buildings, many are not yet operational or networked. Therefore, STM site electricity use is currently measured using a single point meter for all buildings on the site that Xcel Energy uses for billing purposes. Every building in the STM site using natural gas has a gas meter installed that is fully operational.

The NWTC site, similarly to the STM site, is metered for electricity via one meter that Xcel uses for billing purposes. While some individual meters have been installed, metering and measurement is still not complete. Since the NWTC site does not currently have natural gas service, gas meters are unnecessary. They will be installed should service be added, which could happen in the next few years.

The newly initiated metering project will complete electrical metering of all key NREL buildings and selective research loads and will have a number of benefits:

- Enables gathering better data on Lab and building energy use
- Enables further calibration and refinement of the DOE2 model, which will help identify additional ways in which operations can be adjusted or building systems can be changed to lower peak demand charges and overall energy consumption.

Potential NREL Goals

- Incorporate metering into site management and audits and use metering data to identify and implement new energy efficiency projects.

4.2.3.7. Leased Building Energy Use

Federal Agency Goals

EO 13123, Sec 403(e). Model Lease Provisions. Agencies entering into leases, including the renegotiation or extension of existing leases, shall incorporate lease provisions that encourage energy and water efficiency wherever life cycle cost-effective. Build-to-suit lease solicitations shall contain criteria encouraging sustainable design and development, energy efficiency, and verification of building performance. Agencies shall include a preference for buildings having the ENERGY STAR® building label in their selection criteria for acquiring leased buildings….

Performance

NREL can readily implement and benefit from cost-effective efficiency measures at its owned facilities and is required to meet certain criteria for these facilities. Therefore, owned buildings have been the major focus of NREL's efforts. However, over 50 percent of NREL's staff are housed in leased buildings, and none of the leased buildings housing NREL were built using sustainable design principles.

The total electricity use for leased buildings is only currently available for 1999. Due to the lease arrangements, it is difficult for NREL to track its electricity use in leased facilities. Natural gas data for leased facilities is also difficult to track. Only the natural gas used at the JSF is tracked presently. For 1999, it was 1,022 MMBtu. To estimate the electricity and natural gas use in leased facilities other than JSF, electricity and natural gas data was gathered for Building 17 and normalized by square foot. This average rate was then multiplied by the square footage of each of the other leased facilities in DWOP. Energy use for leased facilities is summarized below.

Table 4: Estimated Energy Use in NREL's Leased Buildings (FY 1999)[31]

Energy Use in Leased Buildings	FY 1999	FY 2000
Electricity use included in lease (kWh)	3,335,481	NA
Additional electricity use not built into leases (kWh)	1,955,280	1,741,843
Total electricity use (kWh)	5,290,761	NA
Total natural gas use (MMBtu)	14,582	NA
Total Energy use (MMBtu)	32,634	NA
Normalized Energy use (Btu/ft^2 of leased space)	134,228	NA

NA: Not currently available

Denver West Realty leases NREL a portion or all of Buildings 15 through 17 in the DWOP, while Jefferson County Schools is the landlord for Building 27 in the DWOP. JSF is leased through August 2002 while the D.C. office is leased through 2003.

Current arrangements with Denver West Realty involve adjusting the cost of operations (including utilities) annually based on the Consumer Price Index. Jefferson County Schools fixed the cost of operations for the first three years, while years four and five will be adjusted.

NREL has not yet attempted to renegotiate leases to encourage energy and water efficiency. Any energy saving measures implemented by NREL will not result in any operational savings in leased facilities based on present lease arrangements. This makes implementing NREL-wide energy efficiency programs less attractive financially even though they would be environmentally beneficial. For example, NREL is exploring strategies for reducing energy use through better education of employees regarding computer use. Since over 50 percent of employees have offices in leased space, implementing these measures will likely have longer paybacks overall due to the current lease arrangements.

[31] These figures are slightly different than those provided in NREL's 1999 Baseline Report. This was due to the use of different square footage estimates for leased buildings when extrapolating. Square footage values were obtained from Lisa Burns. See the NREL Assessment spreadsheet "Leased Energy Calculator" worksheet for specific information.

Potential NREL Goals

- Renegotiate leases such that NREL can realize savings from energy efficiency improvement efforts and can better track its energy use in its leased facilities (where over 50 percent of its employees work).

4.2.3.8. Petroleum Use in Facilities

Federal Agency Goals

EO 13123, Sec. 205. Petroleum. Through life cycle cost-effective measures, each agency shall reduce the use of petroleum within its facilities…

Performance

NREL uses small amounts of diesel and propane within its facilities for the operation of emergency generators. Due to the lack of a natural gas line for NWTC, the site relies on propane combustion to run some of its quipment. The estimated amount of diesel and propane used per year on the NREL campus, based on a mix of actual usage data and estimates, is listed in Table 5.[32]

Table 5: Estimated Petroleum Use in NREL Owned Facilities Based on Actual or Estimated Usage (FY 2000)

	Diesel (gal / yr)	Propane (gal / yr)
STM	1,860	0
NWTC	240	48
NREL Total	**2,100**	**48**

Potential NREL Goals

- Improve tracking and reporting of actual petroleum use in facilities.

4.2.3.9. Life Cycle Cost Analysis for Energy and Water Project Investment

Federal Agency Goals

EO 13123, Sec. 401. Life Cycle Cost Analysis. Agencies shall use life cycle cost analysis in making decisions about their investments in products, services, construction, and other projects to lower the Federal Government's costs and to reduce energy and water consumption. Where appropriate, agencies shall consider the life cycle costs of combinations of projects, particularly to encourage bundling of energy efficiency projects with renewable energy projects. Agencies shall also retire inefficient equipment on an accelerated basis where replacement results in lower life cycle costs.[33]

Performance

[32] Calculated from equipment list data sheet provided by John Eickhoff. Data is still preliminary and has not been verified via purchase records.

[33] Section 401 of EO 13123 closely parallels EPAct requirements.

As previously defined in section 3.5.1.1, life cycle cost analysis (LCCA) is a method for evaluating all relevant costs over time of a project or product. See section 3.5.1.1 for a more detailed definition.

Including the life cycle boiler comparison mentioned earlier, NREL has already evaluated its options for alternative fuel vehicles to determine which vehicles have the least environmental impact so that these vehicles can be targeted for purchase. See section 4.3.3.1.1 for more details.

Potential NREL Goals

- Establish LCCA as the norm for evaluation of project feasibility when considering projects that will reduce energy and water use.

4.2.3.10. Criteria for Energy Efficient Buildings

Federal Agency Goals

EO 13123, Sec. 403. Energy Management Strategies and Tools. Agencies shall use a variety of energy management strategies and tools, where life cycle cost-effective, to meet the goals of this order. An agency's use of these strategies and tools shall be taken into account in assessing the agency's progress and formulating its scorecard.…

EO 13123, Sec. 403(c) ENERGY STAR® Buildings. Agencies shall strive to meet the ENERGY STAR® Building criteria for energy performance and indoor environmental quality in their eligible facilities to the maximum extent practicable by the end of 2002. Buildings that rank in the top 25 percent in energy efficiency relative to comparable commercial and Federal buildings will receive the ENERGY STAR® building label. Agencies shall integrate this building rating tool into their general facility audits.

EO 13123, Sec. 403(d) Sustainable Building Design. DOD and GSA, in consultation with DOE and EPA, shall develop sustainable design principles. Agencies shall apply such principles to the siting, design, and construction of new facilities….

Performance

NREL has numerous in-house experts who focus on improving the energy efficiency of buildings full time. The Buildings and Thermal Design team at NREL specializes in developing whole-building design methods and computer programs that integrate passive solar, energy efficiency, and renewable energy technologies to minimize energy use in commercial and residential buildings. The team has worked with numerous private and public entities to develop state-of-the art energy-efficient buildings. It has also helped design a number of NREL's own buildings, including the Solar Energy Research Facility (SERF) and the Thermal Test Facility (TTF), both of which incorporate daylighting and other passive solar technologies as well as other building design measures to reduce overall energy intensity.

NREL currently plans to certify all new buildings to LEED guidelines (see section 4.1.3 on Land Use), as well as to maintain compliance with 10 CFR 435, both of which include guidelines regarding energy efficiency in federal facilities. The ENERGY STAR® Buildings program is

limited to office buildings at present, so it would not be accurate for NREL to try and certify its owned buildings, since none are designated for office work only.

Potential NREL Goals

- Follow LEED Standards to achieve a Gold rating for building design, and apply for ENERGY STAR® certification when available for laboratories.
- Ensure that every new building constructed on the NREL campus is a high efficiency building, in which federal facility performance requirements as outlined in 10 CFR 435 are improved by a minimum of 50 percent.

4.2.3.11. Energy Management Strategies

Federal Agency Goals

EO 13123, Sec. 403(e). Industrial Facility Efficiency Improvements. Agencies shall explore efficiency opportunities in industrial facilities for steam systems, boiler operation, air compressor systems, industrial processes, and fuel switching, including cogeneration and other efficiency and renewable energy technologies.

EO 13123, Sec. 403(f). Highly Efficient Systems. Agencies shall implement district energy systems, and other highly efficient systems, in new construction or retrofit projects when life cycle cost-effective. Agencies shall consider combined cooling, heat, and power when upgrading and assessing facility power needs and shall use combined cooling, heat, and power systems when life cycle cost-effective. Agencies shall survey local natural resources to optimize use of available biomass, bioenergy, geothermal, or other naturally occurring energy sources.

EO 13123, Sec. 403(g). Off-Grid Generation. Agencies shall use off- grid generation systems, including solar hot water, solar electric, solar outdoor lighting, small wind turbines, fuel cells, and other off-grid alternatives, where such systems are life cycle cost-effective and offer benefits including energy efficiency, pollution prevention, source energy reductions, avoided infrastructure costs, or expedited service.

Performance

NREL has strived to design its buildings to operate at maximum efficiency while still meeting programmatic goals. Both when replacing equipment that has passed its useful life and through the use of its periodic energy audits, NREL has continued to upgrade equipment and systems to ensure that they are optimized whenever cost-effective. As already mentioned, the Laboratory has numerous on-site PV panels and is generating some wind power at its wind site that is not being metered. Initial estimates place the peak generating capacity of the NWTC turbines at approximately 800,000 kWh per year.

In addition to addressing the lack of metering at NWTC, NREL is pursuing several other on-site generation projects, including solar hot water, additional PV, expanded wind energy opportunities, and possible bioenergy creation on site. A full listing of current and proposed projects is listed in sections 4.2.6 through 4.2.7.

Potential NREL Goals

- Continue to explore methods for increasing the efficiency of facility heating and cooling systems.
- Continue to pursue off-grid generation using renewable resources and grid-tie hybrid research systems whenever possible (see section 4.2.3.4 for goals related to on-site renewables generation).

4.2.3.12. Air Emissions Created by Facility Energy Use

Due to the low volume of air emissions created at NREL, the Laboratory is currently not required to report its air emissions to Colorado state environmental regulators. However, NREL still collects some air emissions estimates based on equipment use.

Federal Agency Goals

Two sections in EO 13123 address greenhouse gas reduction goals, as do related DOE directives:

EO 13123, Sec. 201. Greenhouse Gases Reduction Goal. Through life cycle cost-effective energy measures, each agency shall reduce its greenhouse gas emissions attributed to facility energy use by 30 percent by 2010 compared to such emissions levels in 1990. In order to encourage optimal investment in energy improvements, agencies can count greenhouse gas reductions from improvements in nonfacility energy use toward this goal to the extent that these reductions are approved by the Office of Management and Budget (OMB).

DOE's P^2E^2 Goal ("Fourteen New Pollution Prevention and Energy Efficiency Leadership Goals," issued in November 1999).. Reduce greenhouse gas emissions attributed to facility energy use by 25 percent by 2005 and 30 percent by 2010, using 1990 as a baseline.

EO 13123, Sec. 404(b). Reduced Greenhouse Gas Intensity of Electric Power.
When selecting electricity providers, agencies shall purchase electricity from sources that use high efficiency electric generating technologies when life- cycle cost-effective. Agencies shall consider the greenhouse gas intensity of the source of the electricity and strive to minimize the greenhouse gas intensity of purchased electricity.

Performance

The only greenhouse gas (GHG) for which data was readily available was CO_2, so this was the only GHG for which emission factors could be developed. Emission factors for the air pollutants CO_2, SO_2, and NO_x were estimated for 1990 and 1997 through 2000. Since emission factors vary from year to year and from state to state, it is more accurate to use updated state-level data than national data. Emission factors for 1997 to 2000 were derived from Colorado utility net generation figures and Colorado utility net emissions data available from EIA. To determine 1990 emissions, NREL used emission factor estimates made for 1993, since that was the earliest year for which emissions and net generation data was available.[34] The emission factors used for

[34] Net generation data for 1997-2000 from EIA, Electric Power Monthly, March 1999 to March 2001, Tables 7-13. Net generation values reduced by 9 percent to account for losses in transmission. Emissions data for 1997-2000 from EIA, Electric Power Annual Volume II, Table 24, 1994 –1999. Emissions data for 1999 was preliminary and emissions data for 2000 was unavailable, so the emission rates were assumed to be identical. For conducting

each year and pollutant are summarized in the table below. These factors should only be considered rough estimates due to some of the assumptions that were required to develop them.

Table 6: Estimated Air Emission Factors for Electricity Use in Colorado from 1993-2000

Year	Emission Factors		
	CO_2 (lbs/kWh)	NO_x (lbs/kWh)	SO_2 (lbs/kWh)
1993	2.25	0.0089	0.0058
1994	2.28	0.0094	0.0061
1995	2.24	0.0088	0.0065
1996	2.27	0.0089	0.0060
1997	2.28	0.0085	0.0059
1998	2.26	0.0082	0.0058
1999	2.24	0.0081	0.0052
2000	2.04	0.0074	0.0047

The above emission factors were applied to NREL's electricity use in owned buildings for 1990 and from 1995 to 2000. Table 7 includes estimates of the emissions of CO_2, SO_2, and NO_x attributable to NREL electricity use based on the estimated emission factors.[35]

Table 7: Estimated CO_2, SO_2, and NO_x Air Emissions Based on NREL Electricity Use in Owned Buildings for 1990 and 1995 to 2000

Fiscal Year	Electricity Use[36] (kWh)	CO_2 (tons)	NO_x (tons)	SO_2 (tons)
1990[37]	2,960,000	3,266	9.95	8.26
1995	12,577,892	14,077	55.42	40.61
1996	14,366,007	16,293	64.13	43.22
1997	13,907,830	15,824	59.13	41.35
1998	14,114,780	15,958	57.72	41.10
1999	15,435,840	17,315	62.85	40.33
2000	15,430,367	15,702	56.99	36.58

Emissions related to NREL's use of natural gas in owned buildings were also estimated. They are listed in Table 8. The estimates were based on measured natural gas usage and emission factors from Volume I of EPA's AP-42 Emission Factors (see footnote for important notes).[38]

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emission factor calculations, the following source was consulted: Stephen R. Peterson, EMISS: A Program for Estimating Local Air Pollution Emission Factors Related to Energy Use in Buildings User's Guide and Reference Manual, NIST, U.S. Department of Commerce, 1995. The methodology used by NREL to construct emission factors was identical to that used by Peterson.

[35] To convert to carbon equivalent, multiply CO_2 values by 12/44.

[36] All electricity use data from Anna Hoenmans, NREL. 1990 data was pulled from DOE's EMS system by Anna Hoenmans and leased facility energy use was subtracted.

[37] 1990 emissions data based on 1993 emission factors, since data was not available before 1993.

[38] All natural gas data from Anna Hoenmans, NREL. AP-42 emission factor data is available via http://www.epa.gov/ttn/chief/index.html. Estimates for natural gas combustion emissions were also available based on equipment information, typical fuel use, and typical operation times estimated or measured by NREL staff and collected by John Eickhoff. However, since the values were based on estimated typical equipment and fuel use and since natural gas emissions rates are relatively constant for most pollutants, it was determined that a calculation

Since the AP-42 emission factors for natural gas combustion are constant regardless of equipment for all pollutants except NO_X and CO, the emissions for most natural gas use could be estimated in a straightforward manner. For NO_X and CO, the emission factors were based on a weighted average of emission factors for NREL equipment as of FY 2000. Therefore, emission values for NO_X and CO are rough estimates for all years other than 2000.

Table 8: Estimated Air Emissions from Natural Gas Consumption at NREL Owned Facilities for 1990 and 1995 to 2000

Fiscal Year	Natural Gas Usage (10^6 cubic feet/yr)	CO_2 (tons)	Total PM (lbs)	SO_2 (lbs)	NO_x (lbs)	CO (lbs)	TOC (lbs)
1990	15.23	1,827,720	116	9	1,487	1,011	168
1995	60.32	7,238,544	458	36	5,887	4,005	664
1996	60.20	7,223,580	457	36	5,875	3,997	662
1997	54.86	6,583,572	417	33	5,355	3,643	603
1998	49.55	5,946,396	377	30	4,836	3,290	545
1999	46.03	5,523,444	350	28	4,492	3,056	506
2000	43.51	5,220,600	331	26	4,246	2,889	479

Lastly, NREL has estimated the emissions associated with the combustion of diesel and propane to run various equipment on site. The estimates were based on emission factors from Volume I of EPA's AP-42 Emission Factors and facility data on equipment types, actual or estimated fuel use, and actual or estimated operation times. These emission values are only available for FY 2000 and should be considered rough estimates due to the uncertainties in measuring equipment use and fuel consumption. The estimates of emissions are summarized in Table 9.[39] For more information on emissions contact John Eickhoff or Maureen Jordan.

Table 9: Estimated Air Emissions from NREL Diesel and Propane Combustion in Owned Facilities (based on FY 2000 data)

Site	CO_2 (lbs/yr)	Particulates (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	TOC (lbs/yr)
Diesel	247,484	443	522	6,509	1,421	497
Propane	1,034,895	33	8	1,159	157	41
TOTAL (lbs/yr)	1,282,379	476	530	7,669	1,578	539

The total emissions of CO_2, SO_2, and NO_x from electricity, natural gas, and diesel and propane usage are totaled in Table 10. As can be seen, NREL emissions of CO_2 have more than doubled since 1990, as have SO_2 and NO_x emissions.

using billing data for natural gas volume might be more appropriate. A comparison of the two methods found that the estimated typical emissions for natural gas fired equipment based on collected data were significantly higher than emissions estimates based on total natural gas volume as billed.

[39] Estimates for all diesel and propane emissions were based on equipment information, typical fuel use, and typical operation times estimated or measured by NREL staff and collected by John Eickhoff.

Table 10: NREL Air Emissions from Electricity Use and Natural Gas Combustion, 1990 and 2000

	CO_2 (tons)	NO_x (tons)	SO_2 (lbs)	Total PM (lbs)	CO (lbs)	TOC (lbs)
1990						
Electricity	6,959	27	35,796	na	na	na
Natural Gas	914	0.74	9.1	116	1,011	168
Total	7,873	28.21	35,805	116	1,011	168
2000						
Electricity	15,702	56.99	73,152	na	na	na
Natural Gas	914	2.12	26.1	331	2,889	479
Total	16,616	59.11	73,178	331	2,889	479

Reducing NREL's GHG emissions attributable to electricity and gas use by 25 percent by 2005 and 30 percent by 2010 to help DOE achieve its goal will be extremely difficult to accomplish. Such an achievement would require large investments in renewable energy technologies. Since GHG emission reduction goals are not based on normalized values (derived using gross square footage or another factor), the growth of an agency automatically makes it very difficult to meet these goals. Those facilities and laboratories that have grown substantially since 1990, like NREL, are particularly challenged to meet the GHG goals of EO 13123 and DOE.

Potential NREL Goals

- Attempt to meet DOE greenhouse gas reduction goals and attempt to extend similar reduction goals to other air pollutants.

4.2.3.13. Ozone Depleting Substances

Federal Agency Goals

DOE, as part of its latest P^2E^2 effort, has two goals related to reducing the use of ozone depleting substances as part of facility equipment. The goals are:

Retrofit or replace 100 percent of chillers greater than 150 tons of cooling capacity and manufactured before 1984 that use class I refrigerants by 2005.
Eliminate use of class I ozone depleting substances by 2010, to the extent economically practicable, and to the extent that safe alternative chemicals are available for DOE class I applications.

Potential NREL Goals

NREL already requires purchasing alternate refrigerants. Halon and certain chlorinated fluorocarbons (CFCs) are not allowed in any new equipment or new materials. All new refrigeration equipment is specified to use non-ozone-depleting refrigerants or EPA-identified safe alternatives.

4.2.3.14. Lighting

NREL has designed its owned buildings to reduce the need for lighting through the use of daylighting and has incorporated energy-efficient lighting systems or retrofitted virtually all of the areas in its owned buildings to energy-efficient lighting systems. NREL has also installed numerous occupancy sensors throughout its owned facilities and in parts of its leased facilities as well. Sensors were recently installed in NREL's D.C. office to curb energy use (see section 4.2.5.7).

Lighting in leased NREL spaces could be further improved, but since NREL does not realize savings from energy efficiency projects in its leased spaces, NREL only incurs a net cost for any upgrades. One remaining project in Golden that will be initiated this fiscal year is a lighting upgrade for part of the FTLB. See section 4.2.6.3 for information on the project.

4.2.3.15. Plug Loads

In an attempt to reduce the energy used by computers, printers, copiers, water coolers, vending machines, and other plug loads, several project ideas are under development or consideration. Adding impetus to this effort is a July 31, 2001 EO from President Bush. The EO requires agencies that procure commercially available off-the-shelf products using external standby power devices, or containing an internal standby power function, to purchase products that use no more than one watt in their standby power consuming mode. If these products are not available, agencies shall—when life-cycle cost-effective, practicable, and where utility and performance are not compromised—purchase products with the lowest standby power wattage while in standby mode.

4.2.3.15.1. Reducing Computer Energy Use

A workgroup has been meeting to develop guidelines for more energy efficient use of computer equipment. The group plans to recommend specific strategies and policies to reduce energy use through the widespread use of tactics such as enabling standby modes, encouraging employees to turn off monitors when leaving the desk for an extended period and turning off computers at the end of the day. A double-sided printing effort is also underway.

4.2.3.15.2. Vending Machines and Water Coolers

Energy saving devices for vending machines are being purchased and installed as part of an ongoing project. See section 4.2.6.6 for details. The use of outlet timers to turn off water coolers during non-business hours is also under consideration. See section 4.2.7 for details.

4.2.3.16. Employee Use of Renewable Energy

Due to the focus at NREL on renewable energy and energy efficiency, many employees are active in practicing energy efficiency both at home and at work. A survey of NREL employees performed recently found that 87 percent of the employees surveyed were either currently using solar panels or purchasing dedicated renewable electricity, or planned to do so in the near future.

4.2.4. Opportunities for Improvement

Leadership in energy efficient building design has helped NREL shape its building designs and construction to achieve significant energy savings in its owned buildings. However, NREL has identified several challenges that if addressed could help improve its performance in this area.

- NREL could improve its on-site generation and purchases of renewable energy to greatly reduce the environmental impacts caused by electricity production and to meet DOE goals. The Lab is currently working to address these issues. If NREL quantifies its savings from upcoming energy efficiency projects, it is allowed to use those savings to purchase renewable energy under EO 13123.

- NREL has no financial incentive to reduce energy use in most of its leased facilities since current lease arrangements include the cost of utilities such as electricity. Any monetary savings that would be gained in owned facilities are lost in leased facilities. This complicates energy projects that include both owned and leased facilities, because the overall payback periods are increased. In addition, data on electricity use at leased facilities is difficult to quantify due to the lease arrangements.

- Additional data collection and monitoring of energy use would allow NREL to accurately track its performance and help identify additional opportunities for energy or emissions savings and enable better quantification of savings after implementation.

- Reducing plug loads and educating NREL employees more on energy efficiency are areas where additional effort could pay off with immediate rewards.

4.2.5. Recently Completed Projects

NREL has focused extensively on improving energy efficiency at the Laboratory, which has resulted in both energy efficient building designs and many energy efficiency projects over the years. Some of the more recent projects completed at NREL are listed below.

4.2.5.1. WindSource for Visitor Center

Purchase of 48,000 kWh of wind-generated electricity per year for the Visitor's Center at premium
Status: Initiated in FY 1997. Ongoing.
Sustainability payback: Reduction of significant amounts of CO_2, SO_2 and NO_x per year. Increase of 0.5 percent in amount of electricity supplied via renewable means to help meet DOE goal of 3 percent of electricity from renewables by 2002 and NREL goal of 10 percent by 2005.
Financial impact: $960 annually since 1999.

4.2.5.2. Insulation for PDU Boiler

Status: Completed in FY 2000
Sustainability payback:
Financial impact: One-time cost of $6,000

4.2.5.3. SERF Lab Cooling Modification

Improvement to SERF cooling system efficiency.
Status: Completed.
Sustainability payback: Savings of 8 MMBtu per year with corresponding reductions in air pollutants.
Financial impact: One-time cost of $25,000 GPP.

4.2.5.4. SERF Fan Coil Upgrade

Status:
Sustainability payback:
Financial impact: One-time cost of $16,100 GPP.

4.2.5.5. SERF Air Intake Louvers

Status:
Sustainability payback:
Financial impact: One-time cost of $14,342 GPP.

4.2.5.6. TCUF Boiler Replacement

Status: Scheduled to be completed December 2001
Sustainability payback:
Financial impact: One-time cost of $120,000 GPP.

4.2.5.7. Occupancy Sensors in D.C. Office

Sixteen occupancy sensors were recently installed in common areas of NREL's Washington, D.C. Office.
Status: Completed FY 2001
Sustainability payback: Increased energy savings in D.C. office
Financial impact: $957

4.2.6. Projects in Development

Projects that are in the process of being implemented or are toward the end of the analysis and approval process are described below. These projects are also summarized in Table 11.

4.2.6.1. Electricity and Gas Metering

Complete metering of all major buildings and some major process loads.
Status: Ongoing.
Sustainability payback: Help calibration of DOE2 models that enable the running of "what-if" scenarios to determine how to cost-effectively reduce energy use in buildings. Can assist in determining time periods and usage patterns that contribute to NREL's demand charges. Responds to DOE concerns that NREL is not effectively monitoring building energy performance.
Financial impact: Phase I, $85,000 GPP FY2001; Phase II, $104,200 GPP FY 2002.

Comments: Goal is to have metering completed by mid-FY 2002. Should take approximately 5 months to complete.

4.2.6.2. Improve SERF HVAC

Increase energy efficiency in the SERF by rebalancing the East Wing supply and exhaust airflows in each non-toxic laboratory to reduce the air changes necessary to achieve the same ventilation.
Status: Will be initiated by end of FY 2001.
Sustainability payback: Reduction of 293,000 kwh/yr (1,000 MBTU/yr). Emission reductions of 300 tons of CO_2, 1,390 pounds of SO_2 and 2,164 pounds of NO_x per year. Reduction in GHG emissions of ~ 2 percent compared to 2000 emissions.
Financial impact: Simple payback of 5 years. One-time cost of $30,000 GPP. Annual savings thereafter.

4.2.6.3. FTLB Lighting Upgrade

Upgrade one of the last areas of old, inefficient lighting in the FTLB to be energy efficient.
Status: Under consideration
Sustainability payback: Savings of 28,454 kWh per year, with corresponding avoided emissions of 29 tons of CO_2, 135 pounds of SO_2, and 210 pounds of NO_x.
Financial impact: One-time cost of about $,000, annual savings thereafter. Simple payback of 8 years.

4.2.6.4. Solar Hot Water for NWTC

Install a solar hot water system on top of NWTC Building 251 to reduce the cost of electrical heating of water and the environmental impact associated with electricity use.
Status: Under consideration.
Sustainability payback: Reduction of 6,000 kWh per year of site use energy, with even greater source energy reductions. Emission reductions of 6 tons of CO_2, 28 pounds of SO_2, and 44 pounds of NO_x. Project also provides site operations staff gains practical experience with the technology and a visual statement of NREL's commitment to sustainable building design.
Financial impact: One-time cost of $6,000. Simple payback of 10 years.
Comments: System will be engineered to withstand strong wind gusts in NWTC area.

4.2.6.5. Personal Metering Pilot

Test the concept of personal metering at the office or task level to provide the data necessary for energy efficiency incentives.
Status: Will be initiated by end of FY 2001.
Sustainability payback: Will provide important insights into employee behavior that will help us know where to target future energy efficiency improvements. Will provide individual feedback to encourage energy conservation.
Financial impact: $6,000 one-time cost, with possible follow-up costs.
Comments: 10 people, 2/person, $300 each. Larger scale implementation of pay for power use will likely be problematic due to different energy intensity for different programs and accounting burdens.

4.2.6.6. Vending Machine Energy Controls

Install electricity demand control devices on most vending machines (includes owned and leased spaces) to minimize electrical use. Vending machines are being monitored to determine their energy consumption. Initial measurements show that the average energy consumption for the cold drink vending machines in Building 27 are 300 watts and 475 watts. Vending Miser energy consumption reduction estimates are 30%, and an additional 20% savings can be realized by turning the lights off in the machines.
Status: Twelve Vending Misers have been purchased and two have been installed on the Building 27 vending machines to test actual energy consumption reduction results.
Sustainability payback: To be determined.
Financial impact: Approximately $142/vending miser. Minimal installation time.
Comments: Since NREL only saves money on utilities in owned buildings at present, payback is approximately twice what it would be if NREL directly paid for its electricity use in its leased facilities. Three vending machines cannot be fitted with devices due to their type. There may be opportunities to eliminate redundant machines in addition to purchasing and installing devices.

4.2.6.7. NWTC Boiler LCA

Perform life cycle assessment of whether to maintain current electric boilers or install new gas boilers at NWTC and develop life cycle cost analysis estimate for replacement.
Status: Analysis to be completed by FY 2002.
Sustainability payback: Initial prediction that life cycle energy use and emissions will be significantly better for natural gas rather than electricity.
Financial impact: Currently unknown.
Comments: Contingent on having gas pipeline installed to NWTC.

4.2.6.8. Small Power Producer Agreement for NWTC

Enables NREL to claim credit for electricity demand offset by wind turbines. Currently this offset is not credited to NREL since it is not measured. Will allow future monitoring of output and possible expansion if feasible.
Status: In progress
Sustainability payback: Gain credit for wind power already generating. This will reduce the cost to meet the 3 percent renewable energy target by 2002, since purchase of wind energy from WindSource of via Green Tags will most likely be the way NREL and DOE meet the pledge.
Financial impact:
Comments:

4.2.6.9. Increased Renewable Energy Purchase

Increase NREL's purchase of "green" electricity to 10% by the end of FY 2002. David Garman recently arranged for DOE to be a founding partner of EPA's *Green Power Partnership*, and pledged that DOE facilities, including NREL, would supply 3 percent of their electricity from renewable sources by 2002.
Status: Purchase completed in September 2001.
Sustainability payback: Based on 2000 data, if NREL garnered 3 percent of its electricity from renewable sources (most likely wind energy) the Lab would prevent the emission of roughly 470 tons of CO_2, 1.1 tons of SO_2, and 1.7 tons of NO_x.
Financial impact: Approximately $50,000 per year.

Comments: Other on-site projects can also help to meet NREL goals. See other project listings.

Table 11: Summary of Energy Projects in Development

ID #	Project Title	Priority	Sustainability payback	Financial Costs and/or Benefits				
				Simple Payback (years)	FY 2001	FY 2002	FY 2003	FY 2004
4.2.6.1	Electricity and Gas Metering		Will enable better facility energy management and cost savings through identification of energy and cost saving projects throughout NREL facilities.	NA	$85,000 GPP	$104,200 GPP	-	-
4.2.6.2	Improve SERF HVAC		Reduction of 293,000 kwh/yr (1,000 MBTU/yr). Emission reductions of 300 tons of CO_2, 1,390 pounds of SO_2 and 2,164 pounds of NO_x per year. Reduction in GHG emissions of ~ 2 percent compared to 2000 emissions.	5	$30,000 one-time GPP.	Save over $6,000 annually	Save over $6,000 annually	Save over $6,000 annually
4.2.6.3	FTLB Lighting Upgrade		Savings of 28,454 kWh per year, with corresponding avoided emissions of 29 tons of CO_2, 135 pounds of SO_2, and 210 pounds of NO_x.	8	One-time cost of $8,000	Save $1,100 annually	Save $1,100 annually	Save $1,100 annually
4.2.6.4	Solar Hot Water for NWTC		Reduction of 6,000 kWh per year of site use energy, with even greater source energy reductions. Emission reductions of 6 tons of CO_2, 28 pounds of SO_2, and 44 pounds of NO_x. Project also provides site operations staff gains practical experience with the technology and a visual statement of NREL's commitment to sustainable building design.	10	One-time cost of $6,000	Save almost $300 annually	Save almost $300 annually	Save almost $300 annually
4.2.6.5	Personal Metering Pilot		Will provide important insights into employee behavior that will help us know where to target future energy efficiency improvements. Will provide individual feedback to encourage energy conservation.	NA	Pilot cost of $6,000			
4.2.6.6	Vending Machine Energy Controls		Savings of 25,000 kWh expected per year, with emission reductions of 25 tons of CO_2, 120 pounds of SO_2, and 185 pounds of NO_x.	4	One-time cost of $1,700	Save about $500 per year	Save about $500 per year	Save about $500 per year
4.2.6.7	NWTC Boiler LCA		Expected to save energy and emissions over the life cycle based on previous comparisons.	?	$2,000 FEMP available	-	-	-
4.2.6.8	Small Power Producer Agreement for NWTC		Would enable NREL to claim credit for electricity demand offset by wind turbines. Currently this offset is not credited to NREL since it is not measured. Will allow future monitoring of output and possible expansion if feasible.	?	?			
4.2.6.9	Increased Renewable Energy Purchase up to 10%		Based on 2000 data, if NREL garnered 3 percent of its electricity from renewable sources, it would prevent the emission of roughly 540 tons of CO_2, 1.3 tons of SO_2, and 1.6 tons of NO_x.		$50,000	$50,000	$50,000	$50,000

4.2.7. Projects Ideas Under Consideration

Projects that are still in the initial stages of development or are in the idea stage are listed below. They are not summarized in table form since information for most of the projects is still somewhat limited. The order in which they appear does not indicate priority.

4.2.7.1. Flexible Scheduling / Telecommuting

Promote existing alternative work schedule program designed to reduce peak demand– such as incentivizing beneficial schedule choices by individuals, specific experimental equipment schedules, closing entire buildings on particular days or weeks, telecommuting
Status: Ongoing evaluation.
Sustainability payback: Telecommuting reduces energy use associated with commuting, which is substantial. See Transportation section for the estimated impacts of commuting.
Financial impact:

4.2.7.2. Monitor Energy Use in Leased Spaces and Consider Lease Negotiation

Request more specific leased facility energy use data and reassess leases to provide incentives for saving energy. Currently, utilities are included in most lease costs. Arranging the leases to allow for savings to be realized is encouraged in EO 13123.
Status: Suggestion.
Sustainability payback: Will provide financial benefits from energy saving projects in leased spaces that include utility costs as part of lease costs and encourage more NREL-wide energy projects.
Financial impact: Possibility for increased risk due to price fluctuations or increased costs if lease not negotiated properly. Potential for some savings, but large savings may not be possible since facility equipment upgrades are not feasible.

4.2.7.3. Very Low Energy Building Demonstration

Partner with Stevinson to build a very low energy (VLE) Showcase Denver West/NREL conference center, hotel, or bed and breakfast on or near NREL site.
Status: Suggestion.
Sustainability payback: Increase NREL Buildings visibility and provide nearby accommodations for visitors.
Financial impact: Any possibility that facility could charge for conferences, accommodations, etc. to recover initial costs and create revenue stream?

4.2.7.4. Increase Use of Solar Hot Water Projects

With reasonable payback periods and proven reliability, solar hot water projects could be expanded for owned buildings. One project is already being developed for NWTC.
Status: Under consideration.
Sustainability payback: Help meet renewable energy goals, reduce emissions associated with grid electricity use, increased visibility for Laboratory.
Financial impact: NWTC project payback approximately 10 years with cost of $5,000 - $6,000 and annual savings of roughly $500 per year. If NREL quantifies its savings from upcoming energy efficiency projects, it is allowed to use those savings to purchase renewable energy under EO 13123.

4.2.7.5. Visitor Center Photovoltaic Extensions

Install cabling that will allow photovoltaic electricity already produced by the Rufus House and Portable Trailer to be used by the Visitor Center. Electricity is currently wasted.
Status:
Sustainability payback: Significantly reduced emissions from energy use, higher life cycle energy efficiency than grid electricity, increased visibility for Laboratory.
Financial impact: $5,000 initially. Cost savings due to energy savings unknown at this time. If NREL quantifies its savings from upcoming energy efficiency projects, it is allowed to use those savings to purchase renewable energy under EO 13123.

4.2.7.6. Photovoltaic-Shading for Existing or New Parking Lots

Transform parking lots into green electricity-producing areas that provide shade for cars.
Sustainability payback: Significantly reduced emissions from energy use, higher life cycle energy efficiency than grid electricity, increased visibility for Laboratory.
Financial impact: High upfront costs.
Comments: Across the entire life-cycle, the entire system of producing and installing the steel supporting structures and panels might have higher energy and emission impacts (and possibly higher costs) than purchasing equivalent amount of wind power annually, installing PV on NREL roofs, using building-integrated PV on future facilities, or other energy projects.

4.2.7.7. Expand Use of Photovoltaics

Expand use of PV on site. May only be feasible if PV producers can be convinced to donate panels at reduced cost in exchange for research data and/or publicity.
Sustainability payback: Significantly reduced emissions from energy use, higher life cycle energy efficiency, increased visibility for Laboratory.
Financial impact: High upfront costs. If NREL quantifies its savings from upcoming energy efficiency projects, it is allowed to use those savings to purchase renewable energy under EO 13123.

4.2.7.8. Expand Wind Generation At NWTC or Remotely Via Agreement

In addition to tying current wind energy production from research turbines, NREL could use a dedicated turbine for energy production.
Sustainability payback: Significantly reduced emissions from energy use, higher life cycle energy efficiency than grid electricity, increased visibility for Laboratory.
Financial impact: Large upfront costs unless can negotiate for turbine donation in exchange for research work or monitoring. Due to gusty and difficult wind conditions at NWTC site, energy production is lower than average, resulting in a longer payback period. If NREL quantifies its savings from upcoming energy efficiency projects, it is allowed to use those savings to purchase renewable energy under EO 13123.

4.2.7.9. Tie Biomass Energy Production to NREL Grid

Grid-tie biomass energy to be produced at FTLB thermochemical user facility (TCUF) in the near future. Up to 30 kW possible.
Sustainability payback: Significantly reduced emissions compared to grid electricity, higher life cycle energy efficiency, increased visibility for Laboratory.

Financial impact: Since NREL will already be using the facility for research, initial costs may be quite reasonable. If NREL quantifies its savings from upcoming energy efficiency projects, it is allowed to use those savings to purchase renewable energy under EO 13123.

4.2.7.10. Reduce Purchases of Redundant Devices Through Policy Changes

The ordering and use of personal printers, faxes, coffeemakers, microwaves, toasters, and other devices could be minimized through policy changes related to purchase cards, ensuring that adequate networked devices exist in all common areas, and ensuring that adequate kitchen devices exist in all kitchen areas.
Sustainability payback: Additional energy savings through reduced plug loads.
Financial impact: Minimal
Comments: While many devices will remain as unnecessary energy loads since they have already been purchased, creating a policy will discourage new purchases and replacement when a device is no longer useful.

4.2.7.11. Employ timing circuits for water coolers

Timing circuits can be used to eliminate most equipment loads during nights and weekends. Water coolers draw 160 Watts average and 630 watts peak when the approximately 32-ounce hot water storage is depleted. Adding a $25 timer to power down after business hours will save energy. There are approximately 4 coolers in STM and an unknown number in the NWTC and in leased facilities.
Sustainability payback: A meter will be installed to determine energy savings that result from timer installation at a pilot site.
Financial impact: To be determined based on results of timer installation.

4.2.7.12. Build a 10,000 ft2 Zero Energy Office Building

Sustainability payback: Add to NREL's Buildings and Thermal Design accomplishments, attract additional interest to program and NREL
Financial impact:

4.2.7.13. Build a 1,500 ft2 Zero Energy Guest House

Sustainability payback: Add to NREL's Buildings and Thermal Design accomplishments, attract additional interest to program and NREL
Financial impact:

4.2.7.14. Education programs for NREL populace

Increase energy awareness in NREL employees through educational seminars and organizational literature. Education programs could stress conservation of energy in the workplace and at home, the availability of WindSource, etc.
Sustainability payback: Additional energy savings.
Financial impact: Minimal

4.3. TRANSPORTATION

The impacts of transportation are not often taken into account by organizations evaluating their environmental performance. However, transportation choices can have large impacts on the environment. NREL has been working toward evaluating and developing strategies to reduce its environmental impacts related to transportation through the encouragement of mass transportation, alternative work schedules, the use of an alternatively-fueled shuttle and bicycle check-out services for travel between buildings, and various other projects.

4.3.1. Federal Agency Goals

A number of legal instruments apply to federal vehicle fleets, including the Energy Policy Act (EPAct) of 1992, Executive Order 13149, "Greening the Government through Federal Fleet And Transportation Efficiency", and related DOE directives.

EPAct Section 303. States that 75 percent of total light-duty vehicle acquisitions in the federal fleet in any given year shall be alternative-fueled, starting in fiscal year 1999.

EO 13149, Sec. 201. Reduced Petroleum Fuel Consumption. Each federal agency operating 20 or more motor vehicles within the United States shall reduce its entire vehicle fleet's annual petroleum consumption by at least 20 percent by the end of FY 2005, compared with FY 1999 petroleum consumption levels.

EO 13149, Sec. 202(b) Acquisition of Higher Fuel Economy Vehicles. Agencies shall increase the average EPA fuel economy rating of non-AFV passenger cars and light trucks acquired by at least 1 mile per gallon (mpg) by the end of FY 2002 and at least 3 mpg by the end of FY 2005 compared to FY 1999 acquisitions.

DOE P^2E^2 Goal ("Fourteen New Pollution Prevention and Energy Efficiency Leadership Goals," issued in November 1999).. Increase the usage rate of alternative fuel in department alternative fuel vehicles to 75 percent by 2005 and 90 percent by 2010 in areas where alternative fuel infrastructure is available. (Note that this is beyond the requirements of EO 13149, which stipulates alternative fuel use in AFVs a majority of the time by the end of FY2005. DOE has interpreted "majority" to mean greater than 50% for all covered agencies other than DOE.)

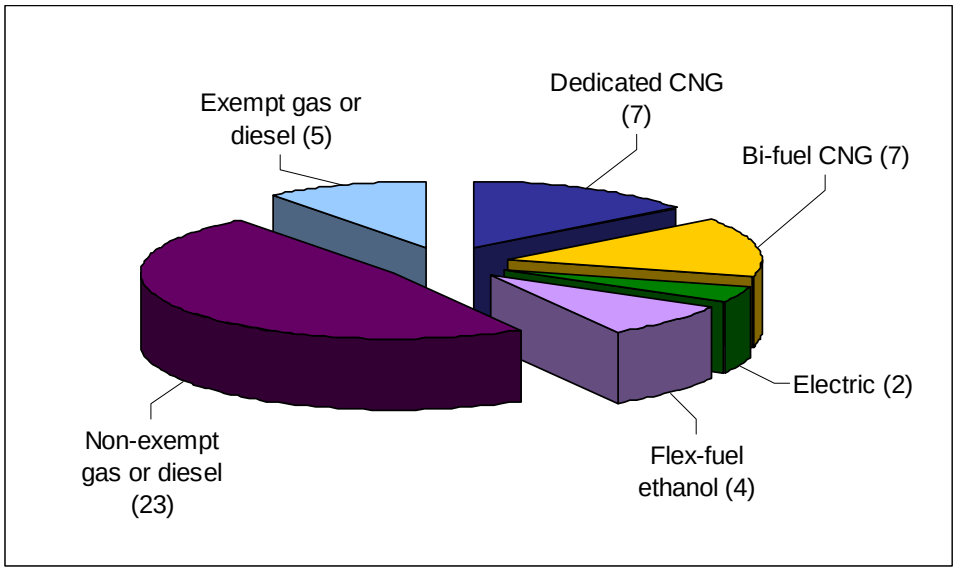
4.3.2. Potential NREL Goals

The following goals were developed to help guide NREL's decision-making concerning transportation issues.

- Build and maintain a vehicle fleet that is the most environmentally preferable possible while still meeting performance, cost, and regulatory requirements.
- Empower and encourage employees to choose the least energy intensive and polluting form of transportation to and from work and while engaged in work-related travel.

4.3.3. Performance and Accomplishments

The performance and accomplishments of NREL in reducing the environmental impacts of



transportation, goals developed, opportunities for improvement, and projects and ideas developed are summarized in the sections below.

4.3.3.1. NREL Vehicle Fleet

NREL maintains a vehicle fleet on-site for maintenance, security, and other work-related uses.

Figure 9 Distribution of NREL Vehicle Fleet (September 2001)

As of 2001, the fleet was comprised of a total of 48 vehicles. All of the vehicles in the NREL fleet are leased through GSA. Therefore, the type of vehicles NREL can purchase, whether conventional or alternatively fueled vehicles (AFVs), is subject to GSA availability and approval. The increase in the percentage of NREL's vehicle fleet that is alternative fueled is shown in Figure 9, while Figure 10 shows the current distribution of NREL's vehicle fleet by type.

Based on data for 5 months, the extrapolated estimate of total miles driven by the NREL vehicle fleet in FY 1999 was 248,486 miles. The miles driven by all fleet vehicles in FY 2000 is 250,968 miles. NREL has four compressed natural gas fuel pumps at its STM site for fueling its 14 dedicated and flexible fuel CNG vehicles. The mileage of the natural gas vehicles is 42,690. The current CNG tanks are all slow delivery systems, which require eight hours to completely fill a vehicle that is near empty. The bi-fuel CNG vehicles can also run on gasoline. It is unknown how often the bi-fuel vehicles are filled with gasoline, although those familiar with fleet operations believe that the bi-fuel vehicles are often filled with gasoline rather than CNG.

Of the four ethanol fueled vehicles, all are designed to run on a blend of ethanol and gasoline from 100% gasoline up to 85% ethanol and 15% gasoline. It is unknown how much ethanol and

gasoline these vehicles consumed or the total miles they were driven. No ethanol service tanks are available on-site, but there is one station servicing this type of vehicle within three miles of the STM site. There are three charging stations on-site for the two electric vehicles at NREL. Two stations are located at the FTLB, and one is located at the NWTC. Generally, electric vehicles take approximately six hours to reach full charge when the batteries become depleted.

4.3.3.1.1. NREL Vehicle Fleet: Life Cycle Assessment to Inform AFV Acquisition

In response to Section 303 of EPAct, NREL committed in 1998 to acquire only AFVs for all non-exempt light-duty vehicles in its fleet. In FY 1999, 80 percent of non-exempt vehicle acquisitions were AFVs, exceeding the EPAct requirement of 75 percent. In FY 2000 and FY 2001, 100 percent of vehicle acquisitions were AFVs, allowing NREL to achieve its goal of acquiring only AFVs when purchasing light-duty vehicles. However, this decision may not be the most sustainable for the laboratory.

NREL recently undertook a study to determine which AFVs had the best environmental performance among the models available to help inform its acquisition process. Models identified as having superior performance would be targeted for purchase by the Laboratory when cost and other factors such as fuel availability and vehicle performance needs could also be met. The Laboratory realized that the most accurate and appropriate manner in which to compare the vehicles would be through the use of life cycle assessment (LCA). Fortunately, an electronic model evaluating the environmental impacts of a number of vehicle types across most of their life cycle was already in existence.

NREL used the GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) Model 1.5a, developed by Michael Q. Wang of the Argonne National Laboratory, to evaluate the environmental impact of several AFVs. The GREET Model 1.5a estimates the energy and air emissions resulting from various fuels used in different AFVs, across the entire fuel cycle. The fuel cycle for a given transportation fuel includes the following processes: energy feedstock production, transportation, and storage; fuel production, transportation, storage, and distribution; and vehicle operations that involve fuel combustion or other chemical conversions.[40]

GREET 1.5a was designed so that users can customize the model based on varying assumptions and facts. NREL adapted the model to account for the electricity generation mix in Colorado by entering values corresponding to the fuel mix used by electricity generators in Colorado. The values entered correspond to those in NREL compared the energy and emissions across the fuel-cycle for the following vehicles:

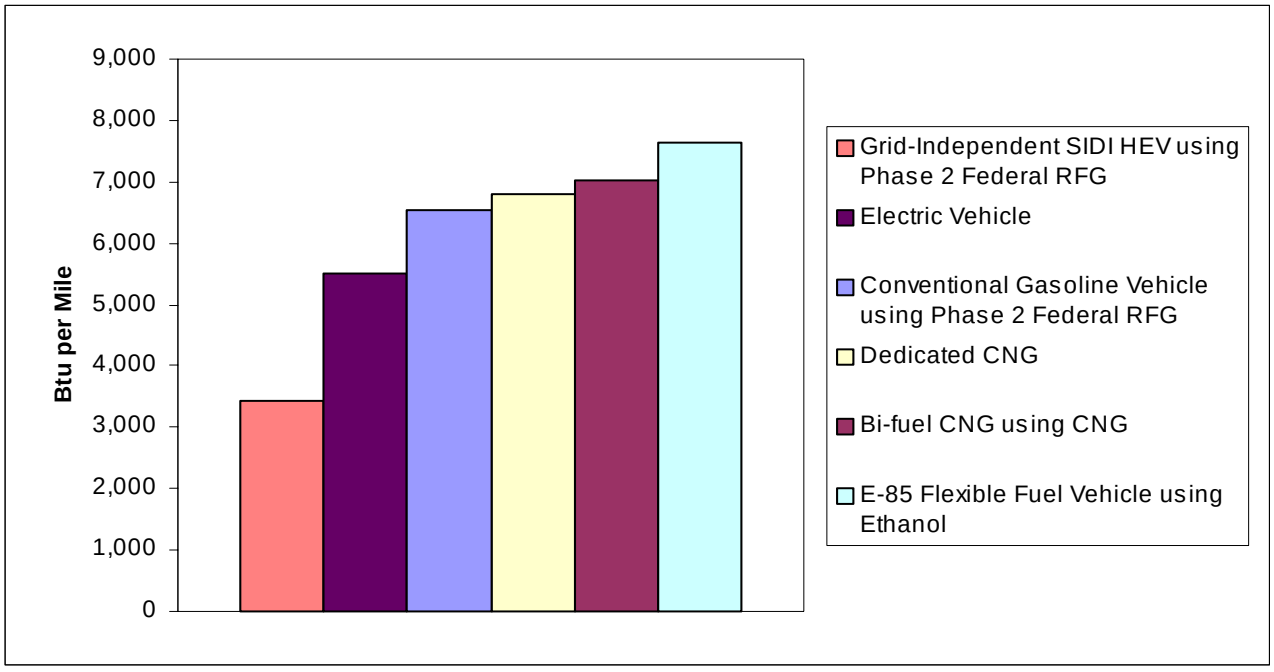
[40] Michael Q. Wang, Argonne National Laboratory, Center for Transportation Research, GREET 1.5—Transportation Fuel-Cycle Model, Volume I, ANL/ESD-39 Vol. 1, August 1999. For information and to download the latest version of the model, go to http://www.transportation.anl.gov/ttrdc/greet/. The GREET Model does not include the life cycle energy and emissions associated with vehicle production or vehicle disposal/recycling. However, the energy and emissions associated with vehicle production and disposal/recycling are small when compared to the energy and emissions associated with vehicle operations—the largest single contribution to energy and emissions across the life cycle—and the fuel cycle stages prior to vehicle operation.

- Grid-independent, spark-ignition direct-injection (SIDI) hybrid electric vehicle (HEV) running on phase 2 federal reformulated gasoline (RFG)
- Electric vehicle
- Conventional gasoline vehicle using phase 2 federal RFG
- Dedicated compressed natural gas (CNG) vehicle
- Bi-fuel CNG vehicle running on CNG
- Ethanol-85 flexible fuel vehicle running on ethanol-85 (a mix of 85 percent ethanol and 15 percent gasoline).

Figure 10 graphs the results of the near-term output provided by GREET Model 1.5a for the total energy use rate in Btu per mile.[41] While total energy use is an important indicator to consider, a better indicator for energy use is the rate of fossil fuel energy use. For example, ethanol has the highest total energy rate based on the GREET model results, but when the fossil fuel energy rate is considered, as graphed in Figure 11, the ethanol vehicle is one of the most energy efficient. Since the rest of the energy use attributed to ethanol vehicles is renewable, the fossil fuel energy use rate is a more appropriate comparison.

Figure 12 graphs the emission rates for greenhouse gases (GHGs) for the same vehicle types, expressed in grams of CO_2 equivalent per mile. Figure 13 graphs emissions of the criteria air pollutants (carbon monoxide (CO), volatile organic compounds (VOCs), sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulate matter less than 10 microns in diameter (PM_{10}).

Figure 10: Total Energy Use Rates for Various Vehicles Across the Fuel Cycle



[41] The near-term output is based on assumptions about near-term technologies and capabilities and intended for use in simulating the impacts of vehicles over a shorter-term time horizon.

Figure 11: Comparison of Fossil Fuel Energy Use Rates for Various Vehicles Across the Fuel-Cycle

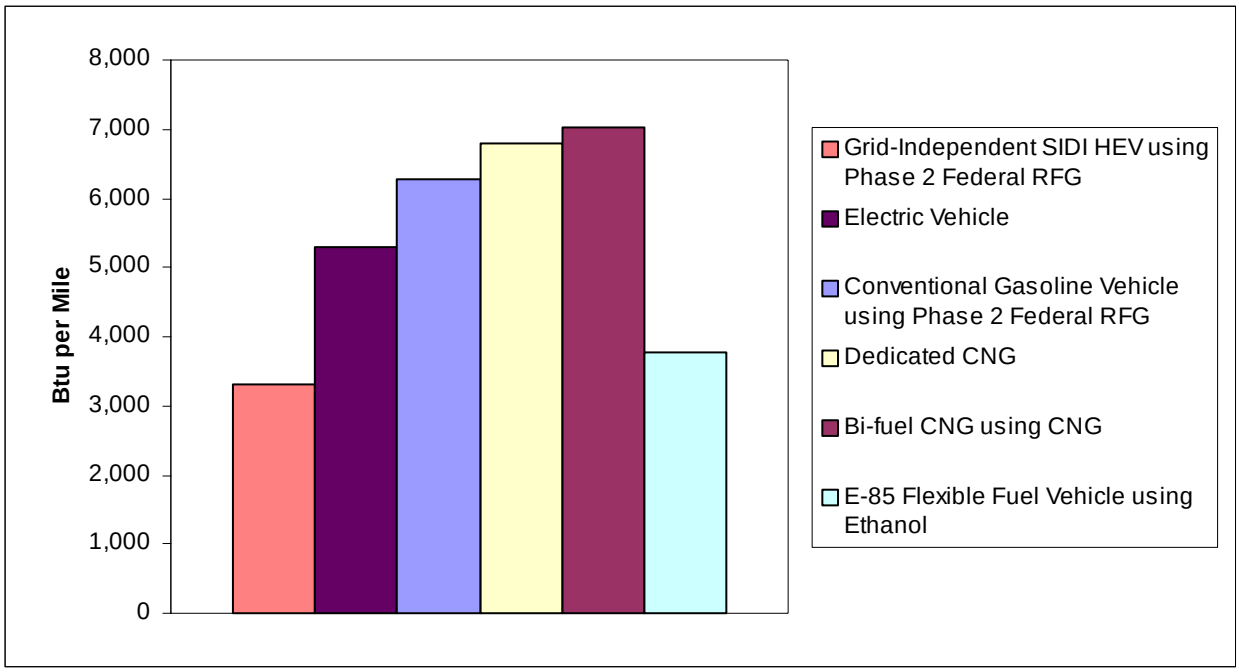


Figure 12: Comparison of Greenhouse Gas Emission Rates Across the Fuel-Cycle (CO_2 equivalent)

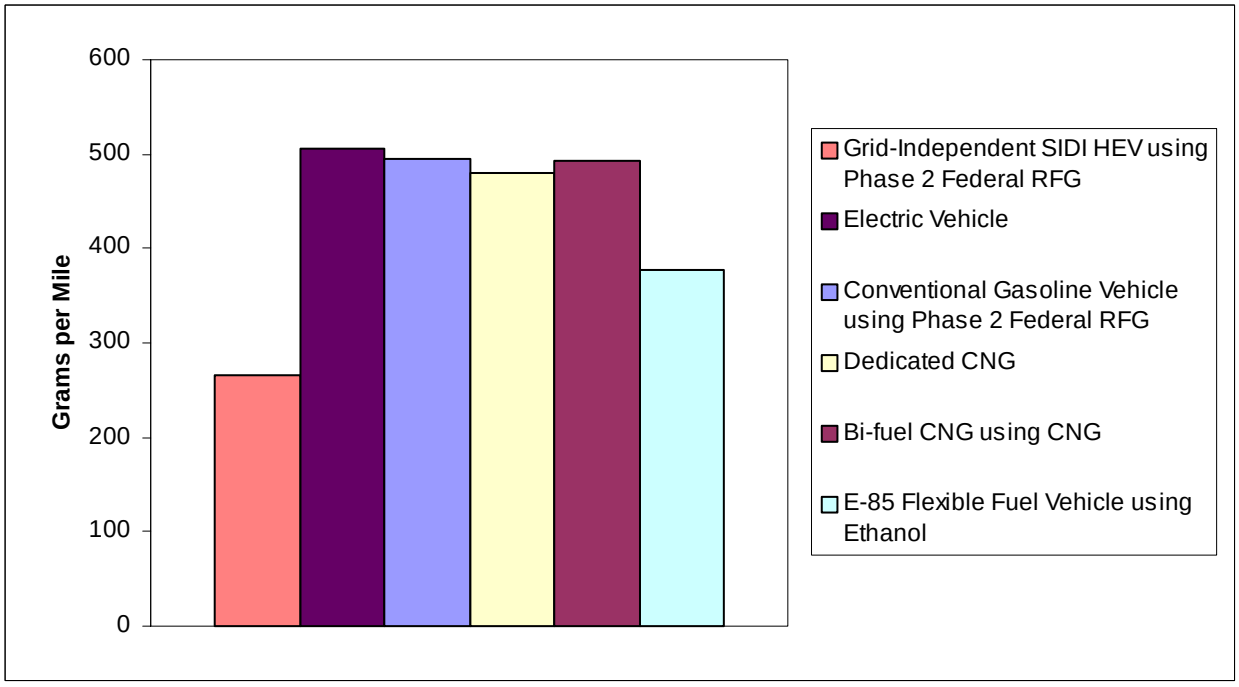


Figure 13: Comparison of Criteria Air Pollutant Rates Across the Fuel-Cycle

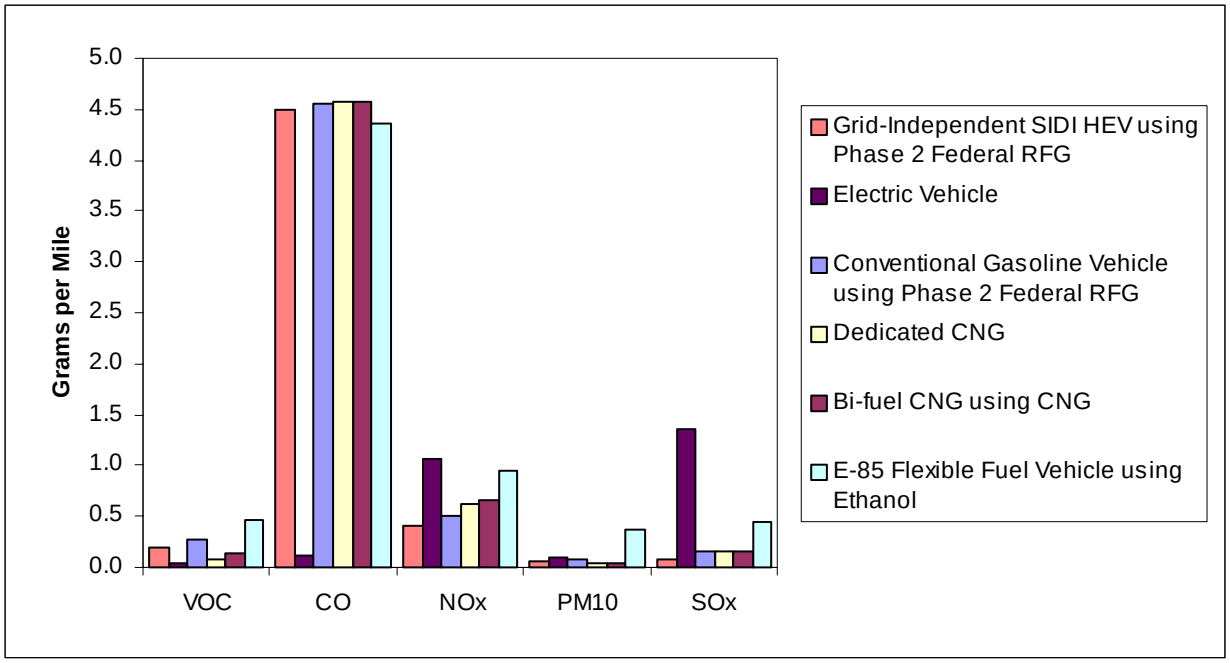


Table 12 summarizes the results of the vehicle fuel-cycle analysis, with rankings of each vehicle across each category of energy use and emissions.

Table 12: Rankings of Vehicle Types Based on Fuel-Cycle Analysis

Vehicle Type	Rank compared to other vehicles analyzed (1 = best)							
	Total Energy	**Fossil Energy**	**GHGs**	**VOCs**	**CO**	**NO_x**	**PM_{10}**	**SO_x**
Grid independent SIDI HEV using phase 2 RFG	1	1	1	4	3	1	3	1
Electric Vehicle	2	3	6	1	1	5	5	6
Conventional gasoline vehicle using phase 2 RFG	3	4	5	5	6	2	4	3
Dedicated CNG	4	5	3	2	4	3	1	2
Bi-fuel CNG	5	6	4	3	5	4	2	4
E-85 flexible fuel vehicle using ethanol	6	2	2	6	2	6	6	5

There are a number of important conclusions that can be drawn from the analysis of vehicle types which could affect future NREL fleet purchase decisions:

- Figure 10 and Figure 11 reveal that the most energy efficient vehicle of the vehicles analyzed according to the GREET model is the HEV running on RFG. Unfortunately, HEVs are not considered AFVs by government standards, so cannot be used to meet AFV acquisition requirements. However, HEVs can help agencies meet the EO 13148 goal of reducing petroleum consumption. Although current models are small in size and may not be ideal for NREL uses, Ford is planning to release an HEV sport-utility vehicle by 2003. The second

most energy efficient vehicle based on fossil fuel use rates is the E-85 powered flexible fuel vehicle, followed by the electric vehicle. Both of these vehicles meet AFV requirements.

- The high rate of coal use in Colorado causes the electric vehicle to perform poorly with respect to GHG emissions compared to an average of the national grid. A cleaner source of energy would improve the performance of electric vehicles compared to these other vehicles.[42] For example, a microturbine generator using natural gas could supply power for the vehicles at a higher efficiency than the grid with fewer emissions. Ideally, an on-site or dedicated renewable energy source could be used to refuel electric cars in the fleet. This would essentially reduce the fossil fuel use rate and emissions of electric vehicles to zero.
- The compressed natural gas vehicles generally perform similar to conventional gasoline vehicles using RFG. In fact, fossil energy use is slightly higher, as are NO_x and CO emissions. CNG vehicles have slightly lower GHG, VOC, and PM_{10} emissions than conventional gasoline vehicles using RFG. Dedicated CNG vehicles outperform Bi-fuel CNG vehicles.
- The E-85 flex-fuel vehicle has the second lowest fossil fuel use rate and GHG emission rate of all vehicles analyzed, but it has comparatively high emission rates for all criteria air pollutants except CO.

Based on the results of the environmental fuel-cycle LCA comparisons, NREL should consider revising its stated goal of acquiring 100 percent AFVs to allow greater integration of HEVs while still meeting the EPAct requirement of having 75 percent of the fleet be alternatively fueled. NREL should also consider purchasing more flex-fuel E-85 vehicles and electric vehicles, while possibly phasing out its use of CNG vehicles. However, there are several important caveats:

- Informal surveys of NREL AFV use have found that flex- and bi-fuel vehicles are often run on gasoline rather than the designated fuel. The use of gasoline in flex-fuel vehicles will result in fuel-cycle energy use and emissions that are possibly even higher than those of conventional gasoline vehicles due to the lower efficiency of vehicles that are designed to run on multiple fuels. Purchase of dedicated CNG vehicles only, upgrade of the CNG FuelMaker pumps to a higher speed fill, and the installation of an E-85 distribution system on-site may help alleviate these difficulties.
- The cost, availability, and performance of different AFVs as well as fuel availability are very important factors to consider when determining which vehicles to purchase. If the range of available electric vehicles is too low for current use patterns or performance is poor, choosing to purchase such vehicles would not be an appropriate decision. A lack of adequate ethanol fueling on-site or nearby would make ethanol-fueled vehicles less attractive an option, especially if employees tend to fuel the vehicle with gasoline.
- Emission performance characteristics vary among vehicles and continues to improve in many vehicles. Overall fuel-cycle emission rates are likely to continue to decline for both AFVs

[42] When a comparison was made between the default assumptions in the GREET Model and the model run using Colorado data, these differences became evident. Using the default assumptions, the electric vehicle had the third lowest fossil fuel energy use rate, just barely trailing the second-place E-85 vehicle. Similarly, the GHG emission rate for the electric vehicle under the default GREET model assumptions was the second lowest overall. Based on the model outputs using Colorado generation factors, the electric vehicle is the worst performer for GHG emissions.

and conventional vehicles. As an example, the latest CNG vehicles have lower emission rates during operation than previous models and some qualify as ultra-low emission vehicles.

Based on the results of the GREET model run, it may be useful for NREL to develop a matrix analysis of AFVs which incorporates the environmental information provided by the LCA with purchase cost and operating cost information for available AFV models, expected range, and any concerns with performance or fuel availability.[43] The results of such an analysis could allow NREL to determine which models achieve the greatest environmental benefits at the lowest cost and with the fewest performance concerns.

While the GREET model is convenient, there are some drawbacks to consider:

- The model assumes use of phase 2 RFG as the fuel for gasoline vehicles – this fuel is only available in select markets which does not include Colorado. Emissions from the gasoline SI and HEV vehicles will increase with the use of conventional gasoline.
- The model doesn't consider the positive aspects of using non-imported fuels such as natural gas and ethanol. AFVs would be favored in a comparison of domestic vs imported energy use.
- The model doesn't include wind energy in its mix for electric power generation. Since ten percent of NREL's own electricity mix is wind generated, the model should be adjusted accordingly; this would lower the LCA for the electric vehicles.
- Exhaust emissions for AFVs are generally much lower than that of conventional gasoline. While emissions from the fuel production site is important, emissions at a stationary source are easier to control.

4.3.3.1.2. NREL Vehicle Fleet: Petroleum Use

NREL will need to substantially reduce its petroleum consumption in future years to meet the requirement of Executive Order 13149. Closely related to the petroleum reduction provision of EO 13149 is the stated DOE P^2E^2 goal of increasing the use of alternative fuels in AFVs to 75% by 2005 and 90% by 2010 ("Fourteen New Pollution Prevention and Energy Efficiency Leadership Goals," issued in November 1999). One of the challenges faced by NREL is the continued use of conventional fuels in alternatively fueled vehicles.

4.3.3.1.3. NREL Vehicle Fleet: Fuel Economy

The fuel economy requirements in Section 202(a) of EO 13149 only apply to 1999 acquisitions of light-duty petroleum fueled vehicles. In the baseline year of 1999, NREL acquisitions of petroleum-driven passenger cars and light trucks had an average fuel economy of 18.9 miles per gallon. In its 2000 acquisitions, average fuel economy jumped to 23 miles per gallon. NREL needs to maintain an average of at least 19.9 miles per gallon in acquisitions of petroleum-fueled light-duty vehicles as of 2002 and 21.9 miles per gallon for acquisitions starting in 2005. It is expected that NREL will be able to meet this requirement.

[43] The Alternative Fuel Fleet Buyers Guide (http://www.fleets.doe.gov/) provides useful vehicle availability and cost information for those considering AFV purchases.

4.3.3.2. Commuting

In June 2000, a transportation survey was conducted to determine the commuting habits of NREL employees and assess the impact of commuting at NREL. A total of 423 employees responded to the survey. Table 13 lists the mode of transportation that respondents indicated was their primary method of getting to work.

Table 13: 2000 Transportation Survey Results

Transportation Type	Responses	Percent of NREL Population
Personal Vehicle	339	80%
Bus	27	6%
Carpool	23	5%
Bike	17	4%
Metro	9	2%
Walk	5	1%
Other	3	1%

Thirteen of the 339 employees who responded that they took personal vehicles to work indicated that they drove infrequently. Therefore, a more accurate count of regular commuters out of those surveyed is 326. An extrapolation was made to estimate the impact of commuting across all of NREL. The assumptions and results of the extrapolation are listed in Table 14.[44]

Table 14: Personal Vehicle Commuting Figures

Category	2000 Survey	Extrapolated Results for all of NREL (2000)
Employees traveling via personal vehicle	326	659
Total miles driven per year	2,151,339	4,348,452
Total gallons of fuel consumed	89,639	181,185
Total energy consumed (MMBtu, combustion energy only)	11,187	22,612
General Assumptions and Data Used		
Number of payrolled employees in 2000		855 (NREL)
Average fuel economy (miles per gallon)		24 (EPA avg.)
Number of days spent commuting to work		226 (assumed)
Average round trip distance (miles)		29.2 (survey)
Combustion energy of gasoline (kBtu / gallon, HHV)		124.8 (DOE)

4.3.3.3. Alternative Transportation

NREL supports employee use of alternative transportation in several ways. Since July of 1997, NREL employees in the Golden office receive a free EcoPass as part of their benefits package.

[44] These figures differ slightly from those reported in the Sustainable NREL 1999 Baseline Report, since several corrections to the previous analysis have been made.

The EcoPass allows employees to use Regional Transportation District (RTD) transportation free of charge anywhere in the RTD service area, which includes most of the Denver metro area and surrounding communities. Table 15 summarizes usage of the EcoPass by NREL employees for traveling to Denver International Airport (DIA) and downtown meetings.

Table 15: EcoPass Use by NREL Employees for Business Travel

Fiscal Year	Mileage Saved	Mileage Funds Saved	Parking Funds Saved
1998	12,318 miles	$4,003.57	$6,724.08
1999	16,714 miles	$5,330.82	$13,385.00
2000 (as of 5/31)	7,705 miles	$2,388.55	$6,756.00

A number of employees also take the bus regularly to work. Based on extrapolated survey data for 2000, an estimated 54 employees took the bus regularly to work, over an average round trip distance of roughly 46 miles. The total estimated number of miles traveled by bus by these NREL employees in 2000 was 557,000 miles.

NREL maintains a shuttle service between buildings on the STM and Denver West sites. This shuttle service is run with alternatively fueled vehicles, and is currently performed on demand for all employees. Each of the larger NREL buildings on the South Table Mountain site and Denver West site also have bicycles to check out for travel between buildings. The SERF building has locker rooms equipped with showers that may be used by bicyclists. At NREL's Washington, DC office, employees are entitled to metro passes worth up to $65 per month.

4.3.3.3.1. Telecommuting

Currently NREL has no formal policy on telecommuting to work, although a small number of employees are telecommuting with managerial consent under an alternative work schedule plan. NREL has limited teleconferencing and video facilities available for staff use. NREL is currently considering ways to increase telecommuting opportunities.

4.3.3.3.2. Alternative Work Schedule

Currently NREL has an alternative work schedule policy that allows employees to work different schedules, including four-day-weeks, with management approval. Eliminating the commute one day per week saves 20% of the normal impact of commuting for these employees.

4.3.3.4. On-Site Travel and Unreported Business Travel

Employees use their cars for personal use and for unreported business travel as well as commuting. The transportation survey also queried employees about this type of travel. Table 16 lists the survey results and the extrapolated estimates of the mileage traveled by all payrolled NREL employees in 2000.

Table 16: On-Site Travel and Unreported Business Travel

Type of Travel	2000 Survey	2000 Extrapolated

	Distance (miles)	Fuel (Gallons)	Distance (miles)	Fuel (Gallons)
Personal business and lunch	203,664	8,593	406,847	17,167
Travel between buildings	78,504	3,312	156,822	6,617
Unreported business	473,808	19,992	946,496	39,937

4.3.3.5. Air Travel

Actual data on the number of miles NREL employees traveled via airplane for business was collected for FY 1999. This data is summarized in Table 17.

Table 17: NREL Airline Travel Statistics

Number of trips	Total Miles	Miles per trip	Air Cost	Hotel Cost	Car Cost	Total Cost	Total cost per trip
3,773	10,121,219	2,683	$2,434,661	$277,537	$120,788	$2,832,986	$750.86

4.3.3.6. Emissions from Transportation

The emission factors and passenger-mile conversions listed in Table - were used to estimate the emissions resulting from NREL-related transportation.

Table 18: Emission Factors and Assumptions Used to Develop Emission Estimates

Pollutant	Passenger Car Emission Factor (g/mile)	Light Truck Emission Factor (g/mile)	Bus Emission Factor (g/mile)	Airplane Emission Factor (g/mile)
Carbon Dioxide (CO2)	362.88	544.32	***see below***	***see below***
Carbon Monoxide (CO)	15.48	20.22	17.07	***NA***
Hydrocarbons (HC)	1.88	2.51	4.82	***NA***
Nitrogen Oxides (NOx)	1.39	1.82	6.49	***NA***
Passenger miles per gallon for bus travel*			200	
Bus CO2 emission factor in pounds per gallon of diesel*			22.4	
Btu per passenger mile for travel by airplane^			4,034	
Airplane CO2 emission factor in pounds per gallon of jet fuel*			21.1	

NA: Not available

* Based on information in NREL's 1999 Baseline Report.

^ From www.bts.gov/ntda/nts/NTS99/data/Chapter4/4-21.html, Bureau of Transportation Statistics, U.S. Dept of Transportation, Table 4-21, 1998 data.

Estimated emissions are included in Table 19. For bus and airplane emissions, passenger miles were factored in to the calculations to properly apportion emissions. Emission factors *per person* per mile for these modes of transportation are much lower than those listed in the previous table, since they carry many more passengers per mile than a personal vehicle.

Table 19: Emissions Associated with NREL Commuting and Air Travel

Pollutant	Passenger Cars (lbs)	Light Trucks (lbs)	All Light-Duty Vehicles (lbs)	Bus (lbs)	Total Ground (lbs)	Airplane (lbs)	Total (lbs)
Carbon Dioxide (CO_2)	1,900,893	2,428,919	4,329,812	62,391	4,392,203	6,381,421	10,773,624
Carbon Monoxide (CO)	81,090	90,228	171,317	433	171,750	unknown	171,750
Hydrocarbons (HC)	9,848	11,200	21,048	122	21,171	unknown	21,171
Nitrogen Oxides (NO_x)	7,281	8,121	15,403	165	15,567	unknown	15,567

4.3.4. Opportunities for Improvement

- Keeping track of the use of alternative fuels and the mileage of AFVs will allow NREL to determine how it is performing in relation to DOE's alternative fuel goal and help identify problem areas that require resolution.
- NREL could reduce the amount of petroleum used on site and improve the amount of alternative fuels used through careful selection of vehicle types and the further development of on-site fueling capabilities.
- The scattered location of NREL's facilities increases vehicular travel between buildings. Over 50 percent of all NREL employees work in NREL's Denver West leased buildings, located across Interstate 70 from the STM site. It is too far to reasonably walk between the STM and Denver West sites. This results in many single-occupancy passenger vehicle trips between buildings by NREL employees (although shuttle service with alternatively fueled vehicles is available to all employees) Bikes have been provided for NREL staff to sign out and use between buildings, but few employees use them.
- Assess the impacts of changing NREL policy to increase telecommuting options and/or to adjust working hours so that entire buildings can be freed of workers on certain days could reduce energy use associated with both transportation and buildings.

4.3.5. Recently Completed Projects

Recently completed transportation projects are summarized below:

4.3.5.1. Life Cycle Assessment of AFVs

As described in section 4.3.3.1.1, a life-cycle assessment of AFVs was recently completed to assist NREL in determining which AFVs were most environmentally preferable.
Sustainability payback: The project has identified several areas in which NREL could improve the environmental performance of its fleet by choosing to purchase different AFVs and consider the acquisition of HEVs. See section 4.3.3.1.1 for details.
Financial impact: Unknown, but not expected to be significant.

4.3.5.2. EcoPass Participation

NREL has been a participating business in the EcoPass program for several years.

Sustainability payback: Increase ability and ease of public transportation use to and from work since service is free. Saves NREL parking and vehicle expenses related to business travel when used. Also encourages use of public transportation outside of work since all metro Denver travel is free under the program.
Financial impact: Annual cost of $40,000.[45] So far, tallied total savings are less than costs. Savings of program are difficult to track because RTD provides no means to scan and log use, so they are self-reported. Therefore, savings are likely underestimated.
Comments: A policy to refuse payment for parking and vehicle costs for business travel except in exceptional circumstances could increase savings of program and cut overall travel costs.

4.3.5.3. Continued AFV Acquisition

AFV acquisition is a continuing process for NREL, but carries additional costs related to vehicle acquisition and fuel provision.
Sustainability payback: AFV purchase is a requirement of EO 13149 and AFVs generally have lower environmental impacts than conventionally fueled vehicles.
Financial impact: All of NREL's light-duty vehicles are leased through GSA. GSA charges to support AFVs, which is an annual expense of roughly $5,880. The incremental cost for each AFV averages $1,200. Through a surcharge program DOE established with GSA, the additional cost of AFVs is shared across all DOE fleets with a $10 per vehicle per month charge to all vehicles (light, medium and heavy) leased from GSA by DOE fleets. NREL incurred one-time capital costs of $10,475 for four electric recharging stations and $35,000 for the CNG stations.[46]

4.3.6. Projects in Development or Under Consideration

The following list of project in development or project ideas have been identified in the transportation area. All of these are summarized in Table 20.

4.3.6.1. Modify Life-Cycle Assessment of AFVs

The GREET model used for the assessment has several drawbacks which should be considered in making final decisions of which vehicles to choose. Organize a group to research other possible models or to modify the current model for determining LCA.

4.3.6.2. Develop Cost-Benefit Analysis to Optimize AFV Acquisition

Expand upon the AFV LCA conducted to identify the goals that NREL needs or hopes to meet, the resources available, vehicles available for NREL purchase, lease and operating costs, performance needs, and environmental impacts. May be best achieved through interdisciplinary employee meetings and group project development. Will allow the development of an optimized AFV acquisition process and a list of recommendations to help ensure that environmental impacts are minimized, costs are kept as low as possible, goals and requirements are met, and overall fleet performance is enhanced or maintained in the future.
Status: Suggestion.
Sustainability payback: Would reduce environmental impacts through increase in alternative fuel use and decrease in petroleum use (thereby helping NREL comply with DOE goals and EO

[45] Source: Lynn Billman.
[46] Source: Lynn Billman.

13149 requirements) and support the purchase of the most environmentally preferable vehicles that still meet NREL needs.
Financial Impact: By carefully considering cost impacts and performance concerns, NREL can avoid unnecessary costs.

4.3.6.3. Eliminate Reimbursement for Mileage to and from DIA and Parking Charges

Status: Suggestion.
Sustainability payback: Will encourage RTD use, increase EcoPass savings, possibly allowing the program to pay for itself. Will reduce travel charges since employees will be responsible if they drive, and will reduce environmental impacts of business travel.
Financial impact: Positive. Will realize savings over current situation, and may result in Eco-Pass program self-sufficiency.
Comments: An appeal process or criteria to avoid paying for mileage and parking may be helpful to ease employee concerns. Perhaps allowing employees to drive to Stapleton Transfer Center and bus from there would provide necessary flexibility while still saving energy. Since the mileage is reduced, parking is free, and buses come every 15 minutes, money can still be saved while employees are less constrained in their options.

4.3.6.4. Implement Fuel Provision Changes and AFV Fueling Policy Changes

One of DOE's goals is to increase the use of alternative fuels to 75% by 2005 and 90% by 2010. EO 13149 requires petroleum consumption be reduced by 20% from 1999 baseline by 2005. The focus of NREL's vehicle fleet management team for several years has been on these goals. However, there are still disincentives to using alternative fuels in some of NREL's AFVs due to long filling times, lack of filling stations nearby, and general difficulty in ensuring that employees use alternative fuels whenever possible. The volume of alternative fuels used by NREL is only partially known, and needs to be better monitored. By providing ethanol on site and upgrading CNG pumps to fast-fill, monitoring fuel use by requiring receipt submittal and log sheets, and identifying employees who are not using alternative fuels regularly, NREL can help increase the use of alternative fuels and reduce petroleum use
Status: Suggestion.
Sustainability payback: Meet DOE goal, reduce emissions and fossil fuel energy use of fleet.
Financial impact: Some incremental costs for more expensive alternative fuels may be incurred.
Comments: This could be part of the proposed cost-benefit fleet analysis project.

4.3.6.5. Increase Ability of Employees to Telecommute

Flexible work schedules are currently allowed with management approval, but more frequent telecommuting is still under consideration. Policies that encourage telecommuting for employees that have long commutes could have a big impact.
Status: Under consideration.
Sustainability payback: NREL facilities would save energy, transportation burdens would decrease, employee happiness would increase. For every 10 miles traveled by one NREL employee via passenger car, almost a half gallon of gasoline is consumed and roughly 10 lbs of CO2 are emitted. The use of teleconferencing could further increase environmental and financial benefits by reducing air travel.
Financial impact: Generally positive based on energy savings, cooling costs saved.

Comments: Particularly applicable to research support staff. Consider a pilot? A federal government telecommuting initiative has saved $150 million annually in facility operating costs. Formal policies exist at Lawrence Berkeley and Pacific Northwest. In a pilot at Sandia, 82 percent of managers felt that advantages of telecommuting outweighed disadvantages.

4.3.6.6. Improve Employee Uses of Alternative Transportation Through Carpool Matching, Vanpools, etc.

A web site to match those looking for carpool opportunities by community could be a useful resource to include on the Source (NREL's intranet). NREL could work with the other agencies and organizations in the area to try and develop vanpools to and from convenient locations or include information on those supporting vanpooling. An AFV van or vehicle might be provided for NREL employee commuting use. RTD might be approached to extend bus routes or times
Status: Suggestion.
Sustainability payback: Reduce energy use and emissions from commuting, which are significant contributors to NREL's overall energy impact and emissions. Foster relationships between NREL employees.
Financial impact: Will save employees money in fuel costs, but will require employee time to develop the program and web site.
Comments: Influence over RTD is unlikely.

Table 20: Transportation: Projects in Development or Under Consideration

ID #	Project Title	Priority	Sustainability payback	Financial Costs and/or Benefits				
				Simple Payback (years)	FY 2001	FY 2002	FY 2003	FY 2004
4.3.6.1	Modify Life-Cycle Assessment of AFVs The GREET model used for the assessment has several drawbacks which should be considered in making final decisions of which vehicles to choose. Organize a group to research other possible models or to modify the current model for determining LCA. Develop Cost-Benefit Analysis to Optimize AFV Acquisition		Would reduce environmental impacts through increase in alternative fuel use and decrease in petroleum use, support the purchase of the most environmentally preferable vehicles that meet NREL needs, and help NREL comply with DOE goals and EO 13149 requirements.	NA				
4.3.6.3	Eliminate Reimbursement for Mileage to and from DIA and Parking Charges		Encourage RTD use & increase EcoPass savings, possibly eliminating deficit in program. Would reduce travel charges and environmental impacts of business travel.	NA				
4.3.6.4	Implement Fuel Provision Changes and AFV Fueling Policy Changes		Meet DOE goal, reduce emissions and fossil fuel energy use of fleet.	NA				
4.3.6.5	Increase Ability of Employees to Telecommute		Reduce facility energy use and transportation burdens, increase employee happiness. For every 10 miles traveled by passenger car, almost a half gallon of gasoline is consumed and 10 lbs of CO2 are emitted. Teleconferencing could increase environmental and financial benefits by reducing air travel.	NA				
4.3.6.6	Improve Employee Uses of Alternative Transportation Through Carpool Matching, Vanpools, etc.		Reduce energy use and emissions from commuting, which are significant contributors to NREL's overall energy impact and emissions. Foster relationships between NREL employees.	NA				

4.4. WATER

NREL currently uses water for applications such as drinking, washing, cleaning, and sanitation. Water is also used in buildings for HVAC cooling/heating systems, and labs at the STM site also use water that has been processed and deionized on site. Small amounts of water are used for irrigation at the STM and NWTC sites. At both the STM site and JSF, water comes from the public water supply. At the NWTC site, water is trucked into the site from the Boulder public water supply and stored in tanks.

4.4.1. Federal Agency Goals

Section 543(b) of the Energy Policy Act of 1992 (P.L. 102-486) states that prior to Jan. 1, 2005, each agency, to the extent practicable, shall install in Federal buildings all energy and water conservation methods with payback periods less than 10 years, as determined by using the methods and procedures developed pursuant to Sec. 544, "Establishment and Use of Life Cycle Cost Methods and Procedures."

Executive Order 13123, while primarily addressing energy use, also promotes the conservation of water.

EO 13123, Sec. 207. Water Conservation. Through life cycle cost-effective measures, agencies shall reduce water consumption and associated energy use in their facilities to reach the goals set under section 503(f) of this order. Where possible, water cost savings and associated energy cost savings shall be included in Energy Savings Performance Contracts and other financing mechanisms.

EO 13123, Sections 502(f) and 503(f). Required DOE to develop guidance for determining baseline water usage and water conservation goals for federal agencies by June 3, 2000. In the guidance provided by FEMP for determining baseline usage and for establishing efficiency improvement goals, requirements for establishing a water conservation planning process and for measuring baseline water usage have been provided[47] However, specific DOE water conservation goals have not been developed for laboratories because of the variation in the types of activities involved.

4.4.2. Potential NREL Goals

General and specific goals related to water use are detailed below:

- Conserve water and minimize water consumption and wastewater discharges throughout NREL operations. Specifically:
  - Use LCCA to evaluate water costs at NWTC (e.g., include all treatment costs) and STM (e.g., include sewerage costs) to inform decisions about water conservation projects.

[47] See the following FEMP web sites; http://www.eren.doe.gov/femp/resources/water.html and http://www.eren.doe.gov/femp/resources/waterguide.html

- Reduce water use per gross square foot by at least 10 percent by 2010 at both the STM and NWTC sites.

4.4.3. Performance and Accomplishments

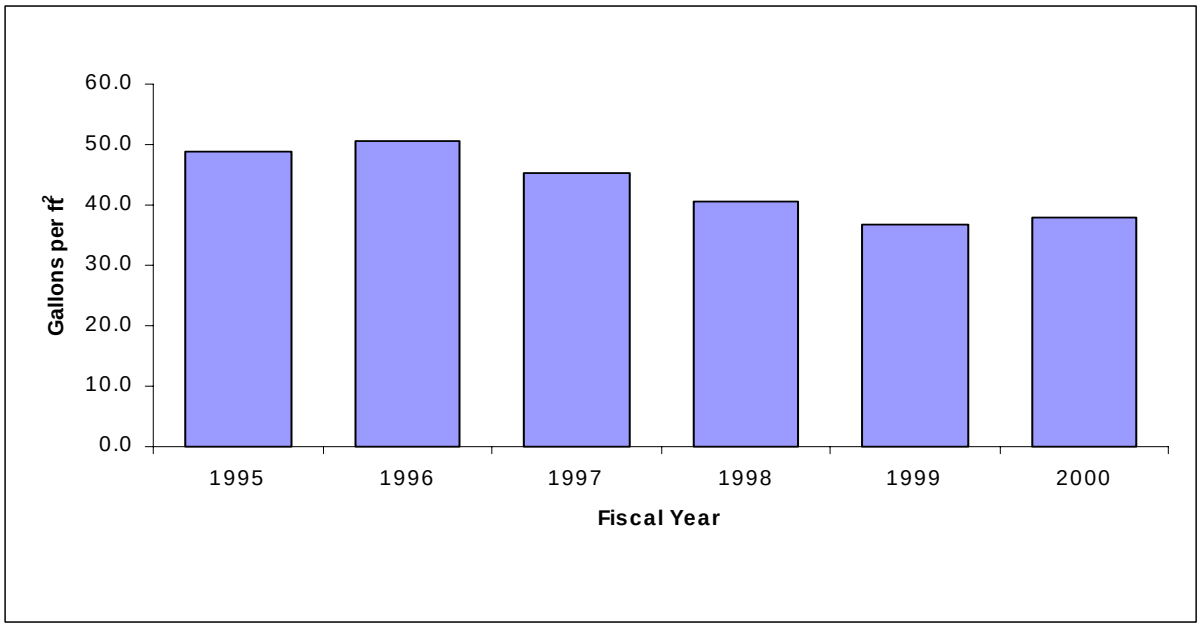
Water use has remained relatively constant over the years at the STM site, even as NREL has expanded in size. But since these figures only account for water use at owned facilities, the increasing use of leased facilities for research support staff is not accounted for. The water use for each building at STM that uses water from FY 1995 – 2000 is included in Table 21.[48]

Table 21: Water Use at STM Site By Building from FY 1995-2000 (gallons, except STM)

Year	STM (10^6 gal)	FTLB	FETA	BTRF	AFUF	MAINT	S/R	SERF	VC	SEB	TTF
1995	13.54	6,488,300	66,400	1,881,100	205,200	77,900		4,768,600	51,000		
1996	14.74	5,483,400	248,800	2,582,800	838,600	2,700		5,233,700	284,000	63,000	2,800
1997	12.97	4,695,900	40,600	625,300	1,218,900	0	42,500	6,073,600	240,700	22,700	7,400
1998	12.27	3,985,800	68,400	321,100	1,234,000	1,400	49,500	6,242,500	207,400	141,500	15,800
1999	12.14	4,770,400	95,100	1,249,700	906,700	5,100	41,300	4,830,600	175,800	29,000	15,200
2000	12.65	5,001,500	108,500	813,000	667,000	2,500	57,500	5,869,500	86,000	28,800	12,400

The water use per square foot at the STM site from 1995 - 2000 is graphed in Figure 14. A metric such as water use per employee might be a more meaningful measurement to use. Unfortunately, it is unknown how many employees were working at the STM site over those years, while gross square footage data for STM was available.

Figure 14: Water Use per Gross Square Foot at STM Site



[48] All water use data provided by Anna Hoenmans, NREL.

The water at the NWTC site is hauled in from the Boulder public water supply by sub-contracted water trucks. The water is stored on-site in a 15,000 gallon underground storage tank and pumped on demand to a 2,000 gallon above-ground storage tank. The 2,000 gallon tank distributes the water as needed to Building 251 and the Industrial User Facility (IUF). Since the water is stored in tanks prior to use, disinfection boosting is necessary. NREL uses a chlorine injection system to treat its stored water, and must subcontract for a state-licensed system operator to run the treatment operations.[49] It is unknown how much the treatment system and operator cost annually.

Data for the NWTC site was only available for FY 1999 and FY 2000. Since all water is trucked into the site, water use is measured by the amount brought to the site annually and may not reflect actual usage since there are storage tanks on-site. The water use is summarized below:

FY 1999 NWTC water use: 208,556 gallons (estimate)
FY 2000 NWTC water use: 223,680 gallons

4.4.3.1. Irrigation at STM and NWTC

NREL uses very little water for irrigation at the STM or NWTC sites, although estimates of use are unavailable. Minimal irrigation is in keeping with NREL policies on landscaping that attempt to minimize alteration of the surrounding natural environment and corresponding impacts. Similarly, very few herbicides and pesticides are used on site, and generally only to control for invasive species. See the landscaping section under the Land Use section of this report and NREL's 1999 Environmental Report for more details.

4.4.3.2. Water Costs at STM and NWTC

The cost per gallon of water at the STM site has not risen substantially over the past six years, as evidenced by the data in Table 22. The cost of water at NWTC has risen a small amount since 1999, and is now 7.5 times more expensive per gallon than water at the STM site.

Table 22: Water Cost per Gallon at STM and NWTC Sites

Year	Average Cost for STM Facilities ($/gal)	Average Cost for NWTC Facilities ($/gal)
1995	$0.0024	NA
1996	$0.0024	NA
1997	$0.0026	NA
1998	$0.0027	NA
1999	$0.0028	$0.018
2000	$0.0028	$0.021

4.4.3.3. Water Use and Cost in Leased Facilities

[49] For more details, see NREL's 1999 Environmental Report, p.19.

The amount and cost of water used in NREL's leased facilities is unknown since the cost of water is included in the lease cost, similar to most of NREL's electricity use. The lease arrangements do not allow NREL to realize any savings by implementing water efficiency efforts at leased facilities.

A large amount of water is used for irrigation at the Denver West Office Park complex. While the amount used is unknown, the grounds at the office park are extensive and sprinklers are run on the property in the early evenings and during the middle of the day in some areas, many of which are spraying water into parking lots and on to roads. To maximize irrigation efficiency, watering should only be conducted late at night or before dawn, should be carefully directed to avoid waste, and should be disabled when there is enough rainfall.

4.4.3.4. Ground Water and Surface Water Runoff

Most of the surface water at the STM site drains into Lena Gulch, a tributary of Clear Creek. During times of extended precipitation, the water could be collected in one of the catch basins around campus. At the moment all of the water in the catch basins drains out to Lena Gulch, and is not reclaimed for landscaping or other uses. However, if this water were reclaimed, it could adversely affect Lena Gulch. In semi-arid areas, reclamation should only be practiced in areas where runoff water is being diverted to sewers rather than natural water bodies.

The surface water resulting from precipitation at the NWTC drains into many streams in the surrounding area. The majority of the water drains into a tributary of Rock Creek.

The STM site has had extensive ground water monitoring in the past. Eight testing wells were installed in 1990 at the STM site in order to verify that NREL was not contaminating the water. Since then, three wells have been plugged in accordance with the State of Colorado. No contamination has been found on the STM site, and NREL continues to closely monitor onsite activities to be sure there are no activities that could pose a risk to groundwater quality.

See NREL's 1999 Environmental Report for more information in these areas.

4.4.3.5. Water Efficiency

A water management study of the NWTC site was conducted in 1999 using WATERGY computer modeling. The study helped identify how water was being used at the site and assisted in developing strategies for reducing consumption. Table 23 summarizes the results of the study.

Table 23: Summary of Domestic Water Consumption, National Wind Technology Center

Bldg	Type of Use	gal/use	uses/day	days/year	gal/day	gal/yr
Building 251						
	Toilets (6)	3	99	260	297	77,220
	Urinals (2)	1.5	66	260	99	25,740
	Faucets (6)	2	31.79	260	64	16,640
	Showers (2)	2.5	40	260	100	26,000
	(1)	3.5	8	260	28	7,280
	Kitchen Sink	2	10	260	20	5,200
	Dishwasher	4	0.2	260	0.8	208
	Shop/Service	3	21	260	63	16,380
	Subtotal				671.8	174,668
IUF						
	Toilets (4)	3.5	27	260	95	24,700
	Urinals (1)	1	18	260	18	4,680
	Faucets (4)	2	8.67	260	17.34	4,508
	Subtotal			260	130.34	33,888
	TOTAL				**802.14**	**208,556**

The study found that toilets consumed about 50 percent of the total water usage at the NWTC. Other large water uses included urinals, faucets, and showers. The study estimated that if NWTC toilets were replaced by 1.6 gpf ULF toilets, it would save 56,000 gallons of water and $1,176 per year in water costs. The replacement of NWTC urinals with waterless urinals could save 16,000 gallons of water and $336 per year. Both toilet and urinal replacement has been approved and is scheduled to be initiated by the end of FY 2001. See section 4.4.5.1 for details.

Other possible improvements suggested by the study included installing more efficient faucets (3,000 gallons saved annually) and showerheads (1,000 gallons saved annually).

4.4.3.6. Wastewater at STM and NWTC[50]

The volume of wastewater discharged by NREL is unknown, although it closely follows total water use after accounting for losses due to consumption and evaporation. In a 12 month period from 1999 – 2000, the total discharge cost for the STM site was $1,848. One of the largest loads fed into the sewer is due to the blow-down from the EVAC cooling towers. In the SERF building, the average blow-down per day is 790 gallons. A new chemical process for treating HVAC cooling tower water is being considered. This process could greatly reduce blowdown as well as both water usage and sewer costs.

The NWTC wastewater is treated by two septic systems that include tanks and absorption fields for the treatment of wastewater. For this reason the NWTC site does not incur any sewage costs other than periodic pumping of solids.

4.4.4. Projects Recently Completed

Recent projects completed are listed below.

[50] Information from 1999 NREL Baseline Report.

4.4.4.1. NWTC Water Management Study

As previously mentioned, an extensive water management analysis was completed for NWTC a few years ago. The study identified areas in which water use could be reduced using the WATERGY model.
Sustainability payback: Identified several areas in which NREL could save water and lower operating costs.
Financial impact: Unknown.

4.4.5. Projects in Development or Under Consideration

Several water projects are currently being implemented or are under consideration.

4.4.5.1. NWTC Water Efficiency Improvements

Upgrade toilets and urinals to low water usage, as recommended in 1999 Water Management Study for NWTC.
Status: Implementing by end of FY 2001.
Sustainability payback: Save approximately 215 gallons per day or 56,000 gallons of water per year. Preserve water use in a semi-arid region. Save energy and costs required for hauling water to site, pumping, and treating.
Financial impact: $8,500 one-time cost with 6 year payback at $0.02 per gallon. Possible savings on treatment costs and energy use for water treatment, although may require additional piping and plumbing work.

4.4.5.2. Upgrade to Low-Flow Toilets at STM

Upgrade toilets in buildings built before 1995 to low-flow standards.
Status: Implementing by end of FY 2001.
Sustainability payback: Save approximately 1,160 gallons per day or 278,000 gallons of water per year. Preserve water use in a semi-arid region.
Financial impact: $23,000 one-time cost with 35 year payback at $0.0028 per gallon.

4.4.5.3. Selective Water Treatment

Consider only treating water that is directed to faucets or only provide potable water in certain locations and educating employees that other water is non-potable.
Status: Suggestion.
Sustainability payback: Reduce energy use associated with water treatment.
Financial impact: Savings on treatment costs and energy use for water treatment, although may require additional piping and plumbing work.
Comments: Would have to check on possible legal concerns.

4.4.5.4. Run WATERGY Models

Run the WATERGY program for all buildings with large water loads, such as the FTLB and SERF.
Status: Suggestion
Sustainability payback: Will allow identification of additional areas in which water could be saved and ensure compliance with EPAct and EO 13123.
Financial impact: Due to low cost of water at STM, payback will be long.

4.4.5.5. Reduce blowdown on all HVAC water towers

Reduce blowdown using new chemical processes and filtering.
Status: Suggestion.
Sustainability payback: Reduced water use and wastewater discharge. However, would need to consider the impact, toxicity, and energy requirements of the chemical process proposed.
Financial impact: Unknown.

4.4.5.6. Follow Water Management Guide

Water Management—A Comprehensive Approach For Facility Managers is included as an appendix to the 1999 Baseline Report.
Status: Suggestion.
Sustainability payback: Identify areas in which water can be conserved.
Financial impact: Unknown.

4.4.5.7. Collect Baseline Data on Wastewater Discharge & Costs

Since water use incurs a cost both for consumption and for disposal as wastewater, total costs are higher than purchase cost alone. Factoring in wastewater costs per gallon would allow more accurate estimates of savings possible from water efficiency efforts.
Status: Suggestion.
Sustainability payback: Additional ability to quantify benefits of water efficiency.
Financial impact: Staff time.

Table 24: Water: Projects in Development or Under Consideration

ID #	Project Title	Priority	Sustainability payback	Financial Costs and/or Benefits				
				Simple Payback (years)	FY 2001	FY 2002	FY 2003	FY 2004
4.4.5.1	NWTC Water Efficiency Improvements		Save approximately 300 gallons per day or 74,000 gallons of water per year. Preserve water use in a semi-arid region. Save energy and costs required for hauling water to site, pumping, and treating.	6	$8,500 one-time cost.	Save $1,100.	Save $1,100.	Save $1,100.
4.4.5.2	Upgrade to Low-Flow Toilets at STM		Save approximately 1,160 gallons per day or 278,000 gallons of water per year. Preserve water use in a semi-arid region.	34	$23,000 one-time cost.	Save ~ $800.	Save ~ $800.	Save ~ $800.
4.4.5.3	Selective Water Treatment		Savings on treatment costs and energy use for water treatment, although may require additional piping and plumbing work.					
4.4.5.4	Run WATERGY Models		Will allow identification of additional areas in which water could be saved and ensure compliance with EPAct and EO 13123.					
4.4.5.5	Reduce blowdown on all HVAC water towers		Reduced water use and wastewater discharge. However, would need to consider the impact, toxicity, and energy requirements of the chemical process proposed.					
4.4.5.6	Follow Water Management		Identify areas in which water can be conserved.					
4.4.5.7	Collect Baseline Data on Wastewater Discharge &		Additional ability to quantify benefits of water efficiency.					

4.5. MATERIALS PROCUREMENT AND DISPOSAL

As with most companies and organizations, NREL depends on everything from photovoltaic cells to paper clips to perform its duties. NREL can generally save money and reduce its environmental impact by:

- reducing materials consumption reusing existing resources whenever possible recycling rather than disposing
- buying recycled
- procuring products that are environmentally preferable across the entire life cycle when compared to alternative products, and;[51]
- developing service oriented contracts for products such as carpeting, ceiling tiles, lighting, computers, and other products, when feasible.

This section includes information on NREL's practices with respect to materials procurement and solid, hazardous, radioactive, and other special wastes generated by NREL. It does not include information on wastewater generation, which is included in the section on water, nor does it include air emissions, which are covered under energy and transportation. The following sub-sections review pertinent federal goals, NREL-developed goals, current performance and accomplishments, and projects for improving performance.

4.5.1. Federal Goals

The Resource Conservation and Recovery Act (RCRA) of 1976 (42 U.S.C. 6962, Section 6002) includes both environmentally preferable purchasing (EPP) requirements and requirements for hazardous and non-hazardous waste handling and disposal. RCRA's purchasing requirements were designed to help stimulate markets for materials recovered from solid waste by using the government's purchasing power. Under RCRA, federal government agencies must:

- give preference in their purchasing programs to products and practices that conserve and protect natural resources and the environment (6962(a),(c),(d))
- establish Affirmative Procurement programs for recycled content products designated by the U.S. EPA (6962(i))

Due to the length of the RCRA waste management provisions, they are not summarized here. In general, RCRA provisions are designed to protect human health and the environment, reduce the generation of hazardous wastes, and conserve energy and natural resources.

Comprehensive Procurement Guidelines (CPG): EPA designates products for government procurement in the CPG. There are currently 54 designated items ranging from construction materials to office products to vehicular supplies.

[51] As a hypothetical example, a plastic clipboard may seem more resource intensive than a laminated wood clipboard, since wood is a renewable resource and plastic is currently derived from fossil fuels. However, the wood clipboard might use more fossil fuel energy, create more solid waste, and emit more pollutants than the plastic clipboard across the entire life cycle. Therefore, the plastic option would be environmentally preferable.

Executive Order 13101, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition" includes goals related to EPP. Applicable requirements are summarized below:

EO 13101, Section 101. Consistent with the demands of efficiency and cost effectiveness, the head of each executive agency shall incorporate waste prevention and recycling in the agency's daily operations and work to increase and expand markets for recovered materials through greater Federal Government preference and demand for such products. It is the national policy to prefer pollution prevention, whenever feasible. Pollution that cannot be prevented should be recycled; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner. Disposal should be employed only as a last resort.

EO 13101, Sec. 102. Consistent with policies established by the Office of Federal Procurement Policy (OFPP) Policy Letter 92-4, agencies shall comply with executive branch policies for the acquisition and use of environmentally preferable products and services and implement cost-effective procurement preference programs favoring the purchase of these products and services.

EO 13101, Sec. 401. In developing plans, drawings, work statements, specifications, or other product descriptions, agencies shall consider, as appropriate, a broad range of factors including: elimination of virgin material requirements; use of biobased products; use of recovered materials; reuse of product; life cycle cost; recyclability; use of environmentally preferable products; waste prevention (including toxicity reduction or elimination); and ultimate disposal. These factors should be considered in acquisition planning for all procurement and in the evaluation and award of contracts, as appropriate. Program and acquisition managers should take an active role in these activities.

EO 13101, Sec. 601(a)(1),(2). Agency Goals. Each agency shall establish either a goal for solid waste prevention and a goal for recycling or a goal for solid waste diversion to be achieved by January 1, 2000. Each agency shall further ensure that the established goals include long-range goals to be achieved by the years 2005 and 2010. …In addition to white paper, mixed paper/cardboard, aluminum, plastic, and glass, agencies should incorporate into their recycling programs efforts to recycle, reuse, or refurbish pallets and collect toner cartridges for remanufacturing. Agencies should also include programs to reduce or recycle, as appropriate, batteries, scrap metal, and fluorescent lamps and ballasts.

DOE ("Fourteen New Pollution Prevention and Energy Efficiency Leadership Goals," issued in November 1999). Goals.

- Increase purchases of EPA-designated items with recycled content to 100 percent, except when not available competitively at reasonable prices or when products do not meet performance standards.
- Reduce sanitary waste from routine operations by 75 percent by 2005 and 80 percent by 2010, using a 1993 baseline.
- Recycle 45 percent of sanitary wastes from all operations by 2005 and 50 percent by 2010.

- Reduce waste from routine operations by 2005, using a 1993 baseline, for these waste types:

Hazardous	90 percent
Low Level Radioactive	80 percent
Low Level-Mixed Radioactive	80 percent
Transuranic (TRU)	80 percent

- Reduce releases of toxic chemicals subject to Toxic Chemical Release Inventory (TRI) reporting by 90 percent by 2005, using a 1993 baseline.
- Reduce waste resulting from cleanup, stabilization, and decommissioning activities by 10 percent on an annual basis.

4.5.2. Potential NREL Goals

NREL is committed to meeting all federal agency-wide and DOE goals. NREL's generally stated goals are as follows:

Minimize the use of materials and energy and the creation of waste by reducing, reusing, recycling, buying recycled, and composting.
Purchase and use recycled content, biobased, and energy efficient materials and products whenever fiscally possible and appropriate.

Before NREL can determine how it is performing with respect to specific federal and DOE goals, the Lab must first obtain more baseline information. Therefore, a key NREL goal is to:

Collect more information on baseline procurement and waste data to improve knowledge, thereby clarifying performance, measuring progress toward meeting specific goals, and identifying areas in which performance can be improved.

4.5.3. Performance and Accomplishments

The availability of data on product procurement and waste generation and disposal at NREL varies according to the product and waste type. NREL tracks certain types of product procurement and collects extensive data on hazardous wastes, non-regulated special wastes, and low-level radioactive wastes. NREL is also provided with recycling data from its recyclables collector. However, as far as could be determined, NREL does not track a number of products it procures that are listed in the CPG, nor does NREL track its generation of sanitary wastes, which is by far its largest source of waste.

4.5.3.1. Purchase of Products with Recovered Content

Table 25 provides information on FY 2000 and FY 1999 NREL purchases of designated products with recovered content. This information was provided by Don Carlisle.

Table 25: Purchases of Designated Items with Recovered Content

Product	Item	FY 1999	FY 2000

Category		Total Purchase	Total Purchase with Recovered Content	Percent Recovered Content	Total Purchase	Total Purchase with Recovered Content	Percent Recovered Content
Paper and Paper Products	Uncoated Printer Paper	$62,000	$58,900	95%	$60,528	$60,528	100%
Construction	Carpeting	$89,000	$8,900	10%	$15,000	$15,000	100%
Construction	Floor Tiles	NA	NA	NA	$40,000	$0	0%
Non-paper Office Products	Toner Cartridges	$22,218	$22,218	100%	$24,595	$24,595	100%

As of 2000, NREL was purchasing all of its uncoated printing paper with recovered content, the vast majority or which was 30 percent post-consumer (PC) in content. NREL currently pays almost $8,000 more per year for 30 percent PC than virgin paper, and the current price paid per box is $28.00. According to Sandra Cannon of PNL, 30 percent PC paper should be available for government purchase for no more than $25.00 per box. It may benefit NREL to negotiate with the current and possible alternative suppliers for a better price. While other paper products with recycled content such as file folders and notepads are required to be purchased with recovered content without exceptions under DOE goals, no information on these items was available.

The percentage of carpet purchased with recycled content dramatically increased from 1999 to 2000. While none of the floor tiles purchased in FY 2000 contained recycled content, there were none available that met performance specifications. Remanufactured toner cartridges provide both economic and environmental benefits. NREL saves about $7,400 annually by purchasing remanufactured toner cartridges as opposed to new cartridges and reduces the number of cartridges going to landfills. NREL indicated no other purchases of products with recycled content in its submissions of data to DOE as part of DOE's affirmative procurement program. It is possible that purchases of other recovered content products were made but could not be tracked.

4.5.3.2. Purchase Cards

One of the major difficulties in tracking purchases of materials with recovered content is the fact that NREL has over 400 purchase card holders, each of which have a $10,000 credit limit. This decentralized system provides useful and appreciated flexibility to program staff, but also makes tracking purchases of materials with recycled content by NREL staff difficult. Since NREL does not have an electronic system for tracking purchases, when staff reconcile their purchases periodically for review, it is done by hand. A number of possibilities exist for improving NREL's tracking abilities and purchasing practices. These project ideas are discussed below and summarized in section 4.5.6.

By upgrading to an electronic, web-based system, NREL could speed reconciliation and data processing. An electronic system also enables tracking of purchases. Pacific National Laboratory (PNL) has developed a software program for purchase card reconciliation that includes mandatory questions regarding whether the purchase contained recovered content and if not, why not (not applicable, cost, availability, performance). The program allows a manager to track the quantity and dollar value of EPA-designated items purchased for the entire Lab and why

products were purchased without recycled content. It does not allow for validation of purchases made by employees and does not track all purchases of products with recovered content. The PNL software is available for free from PNL. NREL is considering adopting the PNL system.

It might be possible for NREL information technology staff to modify the PNL software to enable all possible products containing recycled content to be tracked and to automatically notify users when they have purchased an item without recycled content that is available at a similar or better price with recycled content. This could be incorporated through an updated listing of products, prices, and vendors that is cross-referenced by the software.

Another option for boosting purchases with recovered content could be incorporating training on environmentally preferable purchasing requirements and NREL goals into the purchase card training that is already required. Staff could be provided with access to a spreadsheet identifying all available recovered content products, prices, and vendors in the area, and/or encouraged to visit web sites that list products with recovered content, prices, and suppliers, such as GreenOrder.com, before purchasing an item.

Alternatively, NREL could develop a policy whereby employees must purchase certain items from a list of recovered content products (including prices and vendor contact information), unless written authorization is provided to do otherwise. Not only could the list include EPA designated items, but could also include non-designated items that NREL has deemed superior to other available products. These products would have to be readily available items with lower or similar costs that NREL knows meet performance requirements, and the list would need to be frequently updated.

NREL could enable validation of purchases by requesting vendors to track and periodically report purchases and the employee making the purchase (identified via card number or other means). This service could be requested as part of the contract process, and would serve as an important benchmark of actual purchases. However, it might only be possible for a few vendors that have the capability and are willing to provide the service. Also, the information provided may prove too burdensome to sort through and tally. A more drastic approach would be to centralize all purchasing and require that the centralized purchasing center buy items from EPA-designated lists of products whenever they are cost effective, available and equivalent in performance. This would require a large restructuring and could be opposed by NREL employees due to a loss in convenience and flexibility.

4.5.3.3. Closing the Loop Through Contracting

It is unknown whether NREL has any service contracts for products that include removal and disposal as part of periodic replacement. The use of service-oriented contracts could reduce the amount of waste attributed to NREL activities, reduce the associated disposal costs, and increase NREL recycling rates. Products that may have this type of service available include carpeting, computers and peripherals, copiers, and ceiling tiles.

Carpet companies such as Interface and Collins & Aikman will remove and recycle old carpeting as part of their replacement service. Interface and Collins & Aikman also offer tile carpeting,

which is essentially a series of small carpet tiles that fit together with virtually undetectable seams. Instead of having to remove an entire carpet due to wear in a heavily trafficked section, those tiles most affected can be replaced. This reduces the need to disrupt employees for re-carpeting work and reduces unnecessary waste.

A number of computer companies such as Dell and Gateway offer replacement services to corporate customers that includes picking up and diverting old machines for reuse or recycling if customers order in bulk. Contracts can be developed specifying replacement dates and other services. It may also be possible to have these companies remove the packaging materials of old computers. One difficulty with this system is the general need for bulk ordering. Due to the decentralized system at NREL, most computer purchases are handled by independent departments.

The copier company Xerox offers certain lease services in which copier replacement will be handled by the company and copier recycling is practiced in earnest. Ceiling tile firms will remove and replace old tiles with new tiles, and will take away the old ceiling tiles for recycling into new tiles. Other service type relationships are becoming more popular as suppliers realize their ability to form lasting relationships with clients and as businesses recognize the convenience and savings possible. NREL could explore options for increasing these types of procurement contracts.

4.5.3.4. Sanitary Waste

Sanitary waste, or municipal solid waste, is typical household or commercial refuse. Estimates for NREL's sanitary waste creation were developed based on limited data and estimation. The 1999 NREL Baseline Report provided information on the size of waste containers outside several owned facilities at STM and NWTC and the frequency of removal. To develop estimates, it was assumed that containers were completely full prior to disposal, were emptied regularly throughout the year, and that the density of the waste disposed by NREL was 310 kg/m^3.[52] It is unknown whether any additional waste containers might be used at STM or NWTC (such as at the Shipping and Receiving building, the TTF, the Visitor's Center, etc.), and the actual frequency of removal may vary. Table 26 summarizes the size of waste containers, frequency of removal, and waste estimates developed.

[52] Density estimate from DOE waste assessment for Sandia National Lab, Draft SNL/NM SWEIS, DOE/EIS-0281, April 1999, nepa.eh.doe.gov/eis/eis0281/Appendixes/ AppH.pdf

Table 26: Estimated Annual Sanitary Waste Disposal at Selected Owned Facilities

Facility	Size of Waste Container & Frequency of Removal	Amount removed annually (yd^3, maximum)	Amount removed annually (lbs, maximum)
AFUF	30 yd^3 per week	1,560	815,121
FTLB	20 yd^3 per week	1,040	543,414
NWTC	30 yd^3 per week	1,560	815,121
NWTC	18 yd^3 per month	216	112,863
OTF	4 yd^3 per month	48	25,081
SERF	4 yd^3 per month	48	25,081
SERF	30 yd^3 per week	1,560	815,121
SERL	4 yd^3 per month	48	25,081
TOTAL	-	**6,080**	**3,176,881**

Sanitary waste volumes at leased facilities are currently unknown. The only data available for leased facilities is for JSF, which has a 30 yd^3 container that is emptied once per week. If full, it would create a similar amount of waste per year as the AFUF. However, since JSF is primarily a storage and maintenance facility, the waste container is probably not filled to capacity most of the time.

Since sanitary waste generation estimates are not currently developed for 1993 and current tracking is very limited, NREL will need to develop procedures for estimating its waste generation if it plans to comply with DOE goals of reducing sanitary waste from routine operations. The total annual cost for sanitary waste pickup and disposal in 1999 was $47,364.[53] Using the figures developed for waste generation, the cost works out to approximately $7.80 per yd^3 of sanitary waste.

4.5.3.5. Hazardous Waste and Non-RCRA Regulated Waste

NREL carefully tracks its generation, storage, and disposal of hazardous waste as well as "special wastes" such as oil and grease that are not hazardous but which generally require special disposal. Table 27 provides information on the generation of these wastes over the past several years. Since waste may be stored for some time prior to disposal, actual disposal figures will vary.

Table 27: Hazardous, Non-RCRA Regulated, and Low-Level Radioactive Waste Generated at NREL (pounds)

Waste Type	1994	1995	1996	1997	1998	1999	2000
Hazardous waste (lbs)	7,011	12,328	8,545	9,558	3,173	10.826	6,858
Non-RCRA regulated waste (lbs)	5,042	2,284	11,054	11,223	13,748	9,785	5,640
Radioactive waste (lbs)	N/a	21	85	3	273	27	0

4.5.3.6. Waste Reduction

[53] Figure from 1999 NREL Baseline Report. Sanitary waste is picked up by Summit Waste Services.

The primary waste reduction effort at NREL so far is the Chemical Management System, started in 1993. This effort has focused on reducing the use of toxic or hazardous laboratory chemicals and developing a management system to enable sharing of excess chemicals. Another example of a waste reduction effort were changes implemented by the purchasing department that helped reduce the amount of paper required for purchase order transactions.

A recent review of the environmental and financial effects of reducing paper use highlights the many benefits associated with reduction of demand, even when products are ultimately recycled. The Chemical Management System and the paper analysis are described in greater detail below.

4.5.3.6.1. Chemical Waste Management and Minimization System

NREL developed a chemical management system several years ago that requires employees to follow specific procedures when ordering and storing chemicals to enable accurate tracking. The system also provides excess chemical information on NREL's intranet, allowing all employees to identify where to find excess chemicals for use in laboratory experiments before making any purchases.

Employees have found the system very useful and it has allowed NREL to reduce its purchase of chemicals and any unnecessary disposal.

4.5.3.6.2. Financial Savings and Life Cycle Impacts of Reducing Paper Use

As noted in the materials section, NREL reported purchasing $60,528 worth of uncoated printer paper in FY 2000. All of this paper contained 30 percent post consumer (PC) content. At a price of $28 per box, this means NREL purchased 2,162 boxes. That is equivalent to 10.8 million sheets of paper with a total weight of 53.9 tons. Based on the total number of payrolled employees at NREL in 2000, uncoated 30 percent PC paper use per employee was about 128 pounds.

The energy used and emissions created to produce one ton of 30 percent post consumer paper across the life cycle are listed in Table 29. This data was derived from information developed by a Paper Task Force convened by Environmental Defense several years ago.[54]

Table 28: Energy Use and Emissions to Produce One Ton of Paper Across the Life Cycle

Energy or Emission Type	Amount
Total energy	33.42 MMBtu
Fossil energy	14.99 MMBtu
GHGs	2.53 tons of CO_2 equivalent
Nox	17.34 lbs.
PM	10.87 lbs.
Sox	26.22 lbs.

[54] The information on paper use is available at the Office of the Federal Environmental Executive (OFEE) web site through the paper calculator, available at http://www.ofee.gov/recycled/calculat.htm. The Paper Task Force consisted of representatives from the U.S. Postal Service, Environmental Defense, Time, Prudential, and others. The data developed has been undergone third party review. More details are available at the OFEE web site.

Haz air pollutants	1.53 lbs.
VOCs	4.39 lbs.
Solid Waste	1,911.82 lbs.
Biochemical Oxygen Demand (BOD)	6.23 lbs.
Chemical Oxygen Demand (COD)	72.53 lbs.
Suspended Solids	9.13 lbs.
Effluent Flow	17.46 thousand gallons
Wood	4,853.30 lbs.

If NREL reduced its use of uncoated paper by only 10 percent, it would save $6,040 dollars and reduce the corresponding life cycle emissions and energy use associated with paper use by 10 percent. One way to reduce paper use is through the use of double-sided printing. It has been estimated that it takes 10 times more energy across the life cycle to produce one piece of paper than to copy and image on one side. NREL is currently updating its printers to incorporate duplexers where they are absent.

4.5.3.7. Recycling

NREL has a dedicated staff of volunteer recycling coordinators that have greatly contributed to expanding the recycling program at NREL. Several central locations are available for most recycling needs, with smaller stations throughout NREL owned and leased facilities. The table below lists the items that can be recycled at NREL.[55]

Table 29: Materials Diverted for Recycling at NREL

Recyclable Material	Additional Information
Paper	Most types of paper except absorbent-type papers (dispose) and glue-bound magazines and catalogs (recycle with newspapers).
Newspaper	All newspapers, glue bound magazines and catalogs
Books	All books, magazines, and catalogs can be included.
Corrugated cardboard	All corrugated cardboard except when foam is attached.
Boxboard	Flat cereal box cardboard types
Aluminum and tin cans	
Glass	
Plastics (1 & 2 only)	Only plastics displaying numbers 1 or 2 can be recycled by NREL. No tops.
Batteries	All common small battery types. Cannot be brought from home.
Transparencies	Require pickup by John Eickhoff
Scrap metal	Pickup from work control required.
Toner Cartridges	Place near recycling bins. Required to purchase remanufactured cartridges.
Tyvek envelopes	
Packing peanuts	All types

NREL has its recycling picked up and processed by Tri-R Recycling. As a service, Tri-R also reports the quantities of materials recycled by NREL. Recycling statistics for 1999 as reported in NREL's 1999 Baseline Report are included in Table 31.[56]

[55] This is not a complete list. For comprehensive details, visit http://thesource.nrel.gov/recycle/index.html.
[56] The data sheet provided by Tri-R for 1999 does not agree with the numbers in the Baseline Report, and the data provided by Tri-R for 2000 seems too low. It appears that some of the Tri-R data is not included in the printouts

Table 30: Recycling Statistics for Calendar Year 1999

Recycled Item	Pounds Recycled in Calendar Year 1999
Co-mingled (includes glass, plastic, aluminum cans)	21,471
Newspaper	40,782
Corrugated (cardboard)	12,480 (ESTIMATE)
Clr. Ledger (colored paper)	8,700
Mixed Paper (colored paper, junk mail, envelopes)	68,684
White Ledger (8 ½ X 11 computer paper)	2,024
Office Pack (white paper)	56,577
Destr-Indus (scrap metal)	202
TOTAL	**210,718**

4.5.4. Opportunities for Improvement

There are several challenges facing NREL in the area of materials procurement:

- NREL does not have a system that can track purchases of environmentally preferable products, making the identification of areas of environmentally preferable purchasing in which NREL excels or could use improvement difficult. The decentralized manner of purchasing makes informal tracking too time consuming.
- There is little internal NREL guidance or training currently available that could enable employees to identify and find EPA designated or otherwise environmentally preferable products.
- NREL could further explore options for contracting for product services rather than purchasing products to help avoid the creation of wastes that are difficult to recycle or create additional costs upon recycling or disposal.

NREL faces a number of challenges with respect to reducing waste volumes and striving to meet DOE goals:

- Sanitary waste volumes are not currently tracked or estimated. Estimating or requesting that the waste removal company provide more detailed information concerning waste volume and/or accurate accounts of the frequency of disposal will help NREL identify its waste volume and periods when waste volume is abnormally high. It will also help more accurately quantify the costs related to each unit of waste creation.
- There might be additional ways that NREL can reduce its generation of hazardous and radioactive wastes through the continued expansion of the chemical management system or identification of alternative chemicals available for use that are non-hazardous. However, due to NREL's research work, the Lab may simply be unable to reduce the amount of these wastes created by the percentage that DOE hopes to achieve overall.

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consulted or are incomplete, since data for commonly recycled materials like commingled containers is essentially absent from the Tri-R reports.

4.5.5. Recently Completed Projects

NREL has recently updated its signage on the main collection bins in the FTLB parking lot, to clarify intended material collection.

4.5.6. Projects in Development or Under Consideration

A number of possible project ideas have been suggested by NREL staff to improve NREL's performance in this area. All of them are still suggestions under consideration at this point.

4.5.6.1. Establish Web-based Listing of Preferable Products

Develop a program to provide information on designated and non-designated environmentally preferable products, contact information for local suppliers, and costs compared to similar products that are less "green".
Status: Suggestion.
Sustainability payback: Increase awareness among NREL staff, thereby increasing purchasing of designated (and non-designated) "green" products. Facilitate increased voluntary reporting. Allow tie-in to software program to track purchase card orders. Ensure compliance with RCRA requirements, EO 13101, and DOE goals.
Financial impact: Additional staff time for training preparation and implementation.

4.5.6.2. Use PNL Software to Track Purchase Card "Green" Purchases

Move to electronic system for tracking Purchase Card orders using Pacific National Laboratory software, which includes ability to track the volume, type, and dollar value of recycled content product purchases based on user input. Look into possibilities for customizing software to incorporate information on "green" products and to otherwise educate employees when they are reconciling their purchase cards.
Status: Suggestion.
Sustainability payback: Will enable better tracking and reporting of green purchases as required under RCRA. Will also increase employee awareness. Allows for feedback to specific employees.
Financial impact: Requires staff time for development, implementation, and monitoring. Once established, costs should be relatively low.
Comments: No method for validating purchases in current version of software. For more information, contact Sandra Cannon at PNL.

4.5.6.3. Incorporate Environmentally Preferable Purchasing into Purchase Card Training

Train employees regarding environmentally preferable purchasing, EPA designated items, and their responsibilities regarding purchasing and reporting. If upgrade to electronic system, training will be needed anyway. Provide information on where designated and other "green" products can be found, prices compared to similar products made with virgin materials, and supplier contact information. Encourage reporting of purchases to appropriate NREL contact.
Status: Suggestion.
Sustainability payback: Increase awareness among NREL staff, thereby increasing purchasing of designated (and non-designated) "green" products. Facilitate increased voluntary reporting. Ensure compliance with RCRA requirements, EO 13101, and DOE goals.

Financial impact: Additional staff time for training preparation and implementation.

4.5.6.4. Negotiate Lease or Service Agreements Rather than Purchases

For products like carpeting, copiers, computers, and ceiling tiles, it is possible to establish service agreements with suppliers rather than purchasing items outright. These arrangements generally include provisions by which the company providing the service recycles the old product line at the end of its useful life. By developing such contracts, NREL can immediately reduce some of its sanitary waste levels, thereby saving money, while helping the Lab meet DOE goals.
Status: Suggestion.
Sustainability payback: Allow NREL to avoid waste disposal charges and meet DOE goals for sanitary waste reduction while still purchasing "green" products, when applicable or available.
Financial impact: Additional staff time for training preparation and implementation.

4.5.6.5. Locate Local Vendors in Colorado for Recycled Materials

An effort to buy recycled materials and to recycle construction materials is made by NREL. The largest hindrance to the amount of recycled materials purchased or demolition materials recycled is finding local vendors. A local recycling organization, Colorado Recycles, puts out an annual listing of companies in Colorado who buy/take and sell recycled materials. Additionally, the EPA has a great deal of information on how to recycle construction materials. Please see the appendix of the Baseline Data Report for a list of EPA publications about construction materials recycling.
Status: Suggestion.
Sustainability payback: Allow NREL to increase purchase of "green" products to ensure compliance with RCRA requirements and DOE goals while minimizing construction/demolition waste.
Financial impact: Additional staff time for training preparation and implementation.
Comments: Demolition waste that is part of NREL expansion of existing facilities should be reused on site whenever possible to minimize disposal costs, recycling costs, and/or waste creation.

4.5.6.6. Reduce Purchases of Redundant Devices Through Policy Changes

Already listed as a project under the energy part of this report, this project also is applicable to this section. The ordering and use of personal printers, faxes, coffeemakers, microwaves, toasters, and other devices could be minimized through policy changes related to purchase cards, ensuring that adequate networked devices exist in all common areas, and ensuring that adequate kitchen devices exist in all kitchen areas. This reduces costs to NREL and reduces demand of products and their corresponding environmental impacts.
Sustainability payback: Additional energy savings through reduced plug loads and additional cost savings through reduction of unnecessary purchases.
Financial impact: Minimal. Should result in savings.
Comments: While many devices will remain as unnecessary energy loads and eventually will require recycling or disposal since they have already been purchased, creating a policy will discourage new purchases and replacement when a device is no longer useful.

4.5.6.7. Establish a Web Site for Excess and Reusable Supplies

Start a web site that each department can update periodically notifying people of excess office supplies and reusable supplies available for free across NREL. Could also include non-chemical lab or research supplies. Enable searching, posting, and requests to be entirely web-based for ease of use, which will increase participation.
Status: Suggestion.
Sustainability payback: Reduce unnecessary purchases and associated expenses as well as waste creation.
Financial impact: Initial costs for program development with corresponding savings expected in mid to long-term.
Comments: PNL has already established such a program successfully. Contact Sandra Cannon at PNL for more information. Without adequate publicity and employee notifications, system will probably not be used most effectively.

4.5.6.8. Join WasteWise or Develop Similar Assessment and Goal-Setting System

A voluntary EPA program, WasteWise is designed to help organizations of any type to commit to reducing waste, establish waste reduction goals, track progress, and gain recognition
Status: Suggestion.
Sustainability payback: Will help establish a framework for waste reduction that is currently lacking. Waste reduction results in both financial savings and reduced environmental impacts, often making the financial impact positive overall.
Financial impact: Additional staff time required to develop and implement, but savings could outweigh costs.

Table 31: Materials Procurement: Projects in Development or Under Consideration

ID #	Project Title	Priority	Sustainability payback	Financial Costs and/or Benefits				
				Simple Payback (years)	FY 2001	FY 2002	FY 2003	FY 2004
4.5.6.1	Establish Web-based Listing of Preferable Products		Educate staff and increase purchase of "green" products. Facilitate increased reporting. Allow tie-in to software program to track purchase card orders. Ensure compliance with RCRA requirements, EO 13101, and DOE goals.					
4.5.6.2	Use PNL Software to Track Purchase Card "Green" Purchases		Better tracking and reporting of green purchases and increase in employee awareness. Ensure compliance with RCRA requirements, EO 13101, and DOE goals.					
4.5.6.3	Incorporate Environmentally Preferable Purchasing into Purchase Card Training		Educate staff and increase purchase of "green" products. Facilitate increased reporting. Ensure compliance with RCRA requirements, EO 13101, and DOE goals.					
4.5.6.4	Negotiate Lease or Service Agreements Rather than Purchases		Allow NREL to avoid waste disposal charges and meet DOE goals for sanitary waste reduction while still purchasing "green" products, when applicable or available.					
4.5.6.5	Locate Local Vendors in Colorado for Recycled Materials		Allow NREL to increase purchase of "green" products to ensure compliance with RCRA requirements and DOE goals while minimizing construction/demolition waste.					
4.5.6.6	Reduce Purchases of Redundant Devices Through Policy Changes		Additional energy savings through reduced plug loads and cost savings through reduction of unnecessary purchases.					
4.5.6.7	Establish a Web Site for Excess and Reusable Supplies		Reduce unnecessary purchases and associated expenses as well as waste creation.					
Error! Reference source not found.	**Error! Reference source not found.**		Additional reductions in chemical waste creation.					
4.5.6.8	Join WasteWise or Develop Similar Assessment and Goal-Setting System		Establish framework for waste reduction, resulting in financial savings and reduced environmental impacts.					

4.6. INTEGRATED MANAGEMENT

4.6.1. Ideas for Improved Overall Management

1. Create sustainability coordinator or environmental manager position as part of site operations
    - Would require enough authority to ensure that project implementation can be achieved without significant delays
    - Person would need experience in implementing projects to reduce environmental impacts.

2. Implement continuing data collection efforts where baseline and/or continued data collection is necessary and combine into electronic system
    - Several sources of information are not being collected which would be useful for measuring progress toward goals
    - Developing a central electronic repository of information on energy use, water use, waste, etc. will enable employees to see Laboratory impacts and incorporate updates easily.

3. Develop teams or specific employees responsible for investigating suggested projects and/or developing suggestions.
    - Establish head contacts for projects that will investigate financial and environmental impacts (and social too, if relevant).
    - Identify volunteers willing to share expertise, their area of expertise, and their available time commitment.
    - Encourage review of ideas by staff not directly involved but with relevant experience.

4. Reward employee efforts and accomplishments
    - Victories and project completions should be celebrated and publicized. Fosters increased awareness and education.
    - Employees should be recognized for overseeing and contributing to successful projects.
    - Consider financial compensation for employees that develop cost-saving measures that also result in an environmental benefit.

5. Increase education efforts
    - Increase overall educational campaign via company literature and employee efforts.
    - Encourage development of sustainability educators for specific buildings that will work to increase awareness.

5. POTENTIAL PERFORMANCE SCORECARDS
5.1. FINANCIAL PERFORMANCE SCORECARD

Category	1995	1996	1997	1998	1999	2000	% change (95-00, or earliest to latest yr)
FINANCIAL							
Total funding (millions)	$250.0	$181.0	$158.0	$179.9	$191.6	$186.7	-25.32%
Operating funds (millions)	$237.0	$175.0	$149.0	$171.7	$185.4	$190.0	-19.83%
Operating cost per research FTE ($ / FTE)	$178	$165	$160	$156	$160	$151	-15.17%
Direct labor multiplier	3.29	3.10	2.90	2.76	2.96	2.89	-12.16%
Uncosted obligations (millions)	$157	$129	$99	$72	$65	$66	-57.96%
Ratio of research to support staff (FTE)	1.88	1.88	1.84	2.05	1.98	2.06	9.57%
Ratio of research to support spending ($)	$1.58	$1.80	$1.86	$1.96	$1.90	$1.88	18.99%
Productivity of Subcontracts (Dollar value of subcontracts (millions) / FTE utilized), (higher = better)	$2.9	-	$3.9	$4.2	$3.8	$3.5	20.69%
Maintenance Costs ($/sq ft)	-	$3.33	$3.24	$3.18	$3.28	$3.45	3.60%

5.2. ENVIRONMENTAL PERFORMANCE SCORECARD

Category	1995	1996	1997	1998	1999	2000	% change (95-00, or earliest to latest yr)
ENVIRONMENTAL							
Land Use							
Built space (total owned and leased facility space (ft2))	640,912	691,825	566,315	584,283	625,579	628,531	-1.93%
Built space (owned space only)	303,505	317,712	324,089	339,709	382,455	385,599	27.05%
Parking lots and roads on owned land (estimated, ft2)	-	-	-	-	1,189,060	-	***na***
Preserved open space due to easements (% of total)	-	-	-	-	31%	-	***na***
Percentage of owned land that is preserved or undeveloped	-	-	-	-	93%	-	***na***
Energy							
Estimated energy use for all owned and leased buildings (Btu / ft2)	***na***	***na***	***na***	***na***	210,480	***na***	***na***
Estimated electricity use for all owned and leased buildings (Btu / ft2)	***na***	***na***	***na***	***na***	113,592	***na***	***na***
Natural gas use for owned and leased buildings (Btu / ft2)	***na***	***na***	***na***	***na***	96,887	***na***	***na***
Energy use in owned buildings (Btu / ft2)	310,337	315,329	277,638	262,153	258,554	249,786	-19.51%
Electricity use in owned buildings (Btu / ft2)	141,401	154,281	146,421	141,767	138,136	136,961	-3.14%
Natural gas use in owned buildings (Btu / ft2)	168,936	161,048	143,892	123,990	120,351	112,824	-33.21%
Electricity use from on-site renewables generation or green energy purchase (%)	***na***	***na***	***na***	***na***	0.64%	0.64%	***na***
Employees surveyed indicating they use solar technologies or purchase, or plan to purchase, "green" energy for their home	-	-	-	-	87.4%	-	***na***
Energy: Associated Emissions							
CO2 emissions from owned facility energy use (tons)	17,696.64	19,905.13	19,116.19	18,931.27	20,076.87	18,312.10	3.48%
Normalized CO2 emissions from owned facility energy use (lbs / ft2)	116.62	125.30	117.97	111.46	104.99	94.98	-18.55%
Combined SO2 and NOx pollutant emissions from facility energy use (tons)	98.99	110.30	103.17	101.26	105.44	95.70	-3.32%
Normalized SO2 and NOx pollutant emissions from facility energy use (lbs / ft2)	0.65	0.69	0.64	0.60	0.55	0.50	-23.90%
Transportation							

Commuting (miles / employee)	-	-	-	-	4,485	-	***na***
Business travel (air miles / employee)	-	-	-	-	10,317	-	***na***
Proportion of NREL fleet that is alternatively fueled	-	20%	20%	28%	52%	52%	160%
Water							
Total water consumption in owned buildings (gal)	13,538,500	14,739,800	12,967,600	12,267,400	12,345,300	12,870,380	-4.93%
Normalized water use in owned buildings (gallons / ft2)	48.80	50.54	45.24	40.60	32.28	33.38	-31.60%
Materials Procurement and Disposal							
Number of CPUs (estimated, includes laptops)	***na***	***na***	***na***	***na***	***na***	1,501	***na***
Number of monitors (estimate)	***na***	***na***	***na***	***na***	***na***	918	***na***
Paper used per year (tons)	***na***	***na***	***na***	***na***	52.43	53.91	2.82%
Sanitary waste (lbs, owned buildings)	***na***	***na***	***na***	***na***	***na***	3,176,881	***na***
Sanitary waste (lbs per employee per yr, owned bldgs)						3,716	***na***
Hazardous waste generated (lbs / employee)	12.83	10.32	***na***	***na***	39.79	9.66	-75.72%
Low-level radioactive waste generated (ounces / employee)	0.29	1.34	***na***	***na***	0.43	***na***	47.69%
Estimated proportion of recyclable materials disposed as waste (%)	***na***	***na***	***na***	***na***	***na***	41%	***na***

5.3. PUBLIC RESPONSIBILITY SCORECARD

Category	1995	1996	1997	1998	1999	2000	% change (95-00, or earliest to latest yr)
Public							
Total number of staffs	1147	1018	942	950	981	1045	-8.89%
Number of payrolled employees	961	828	737	836	845	855	-11.03%
Minority managers (group, program, and senior)	-	-	-	-	-	6.3%	***na***
Female managers (group, program, and senior)	-	-	-	-	-	29.7%	***na***
Proportion of employees with advanced degrees	-	-	-	-	-	39.9%	***na***
Proportion of employees with favorable opinion of their job	-	-	-	-	-	93.0%	***na***
Proportion of employees that feel adequately trained	-	-	-	-	-	90.0%	***na***
Proportion of employees that stated salary is as good or better than at similar organizations	-	-	-	-	-	32.0%	***na***
Socio-economic subcontractor awards (%)	72	***na***	80	80	66	-	-8.33%
NREL injury / illness rate (BLS formula)			1.1	2.2	1.26	1.3	18.18%
NREL workers' compensation costs (private industry formula--value less than $0.25 considered good)	***na***	***na***	$0.07	$0.03	$0.02	$0.04	-42.86%

- Outline of each category and associated goals and project